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ESTIMATION OF THE DEMAND FOR  
PUBLIC SERVICES COMMUNICATIONS  
FINAL REPORT



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FINAL

ESTIMATION OF THE DEMAND FOR  
PUBLIC SERVICES COMMUNICATIONS  
FINAL REPORT

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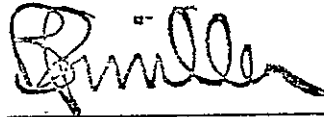
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## Note of Transmittal

This study of the demand for selected advanced communications services that could be provided by a Public Services Communications Satellite System was performed for NASA by ECON, Inc., under Contract Number NASW-2558, Modification No. 7. This work was performed as a part of a 90-day task, beginning September 1, 1974, and was completed on November 30, 1976. The principle contributors to this study were Mr. Philip Abram, Ms. Christine Braen, Ms. Celia Drumheller, Mr. Joel Greenberg, Ms. Larrain Luckl, Dr. Kan Young and Mr. B. P. Miller. The authors wish to express their gratitude to Mr. D. Dement, Dr. E. Mercanti, and Dr. E. Wolff of NASA for their assistance in identifying and obtaining the data needed for this study.

A handwritten signature in dark ink, appearing to read 'B. P. Miller', is written over a horizontal line.

B. P. Miller  
Vice President

## INTRODUCTION

NASA is currently conducting an in-house planning study for a Public Services Communications Satellite System. As currently envisioned,\* the system will provide services to users in the areas of:

- Health Services,
- Education Services,
- Mobile Communications,
- Data Transfer and
- Teleconferencing.

In support of this study, ECON has performed preliminary market analyses and economic studies to estimate the demand for these advanced communications services. As is conventional in economic terms, demand is defined as the quantity of a given service demanded by consumers of that service at any given price. The results of these studies and analyses are described in this report.

It should be noted at the very outset that the reported results are based upon a 90-day effort. The short duration of the study effort had a profound effect on the data sources which were available for use and therefore the methodologies which were developed for evaluating the demand functions. This must be considered when utilizing the reported results. Furthermore, the impacts of institutional, legal, or political factors on the demand or on the ability of a public corporation to satisfy the demand were not considered in this study. For example, problems of malpractice insurance could impede the implementation of a telemedical service for thinly populated areas. While problems of this nature do not change the demand for services, the ability of the government or a public corporation to satisfy the demand could be affected. These problems are important and should receive consideration in subsequent studies.

Also as a result of the time constraint of this 90-day task, the approach to estimating the demand in each of the above areas was to select one function within each area, and thence to examine the demand for the selected service at a highly aggregated level. For example, in the mobile

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\* Preliminary Plan for the Public Services Communications Satellite System, NASA GSFC, September 1976.

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communications area the demand for a national "telephone-in-the-car" service for personal and business use was examined. This telephone-in-the-car service would provide the capability for the car phone to ring simultaneously with the home or office phone (i.e., an extension in the car), or the capability to transfer calls from home or office phone to the car phone. No attempt was made to define the system needed to provide this service. The demand for this service was estimated as a function of its price. In the process of examining mobile communications, other possible functions were considered such as:

- Communications from support ships to offshore platforms,
- Vehicle location systems, and
- Communications between commercial aircraft passengers and the ground on long distance flights (i.e., a pay phone in commercial passenger aircraft).

The phone-in-car service was selected on the basis of an anticipated broad national market for the service, and the relative availability of data to support the analysis of the demand for this service as compared to the other functions considered. In each of the five areas a similar process of selection was utilized in order to choose a function to be analyzed.

In order to place the estimation of the demand for the above advanced services within the context of the historical and forecasted behavior of the traditional telecommunications (telephone and telegraph) industry, a previously developed econometric model of the demand and supply of telecommunication services in the U.S. was updated. This model relates productivity in the traditional sector of the telecommunications industry to research and development expenditures, and estimates the demand function for these services. The results of this rigorous analysis of the traditional sector of the telecommunications industry are reported in order to establish a framework for estimating some of the economic parameters of the more advanced services.

Following a discussion of the economic behavior of the telecommunications industry (i.e., the concept of and the results from the econometric model) the rationale are developed for estimating the demand for public services communications in the areas of medical communications services, educational communications services, personal mobile communications, electronic message/data transfer and teleconferencing. Realizing that there is insufficient historical data for these new services, it was not possible to use an econometric model to forecast the demand for these new services. In order to estimate demand for these new services available economic data was surveyed and used to forecast consumer behavior. For each service considered, estimates of the quantity of that service that would be demanded by prospective users as a function of price are developed and presented. Finally, conclusions are drawn from the results and recommendations for further studies and analyses are presented.

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ECONOMETRIC MODEL OF THE  
TELECOMMUNICATIONS INDUSTRY

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## Purpose

The first purpose of the econometric modeling effort is to predict the future demand for telecommunications services. The two components of the predicted demand are the personal consumption expenditures and the business and government expenditures. The projections are based not only on the growth trends in this historical data but also on the interaction among the variables, such as interaction between the price and the quantity demanded. Associated with the demand projection is the prediction of the input requirements for both capital and labor to assure that the production level meets the demand level.

The second purpose of the econometric modeling effort is to quantitatively evaluate the interrelationship among the variables. Both the direction of change and the magnitude of change are shown for demand when there are changes in either prices or income. The direction and magnitude of changes in production and prices when R&D expenditures change are also shown.

### Purpose

- To predict the future demand for telecommunications services
  - Individual expenditures
  - Business and government expenditures
- To evaluate the sensitivity of:
  - Prices on demand
  - Income on demand
  - R&D spending on production
  - R&D spending on prices

## Approach

In order to model the telecommunications industry and to evaluate the quantitative interrelationships among the variables, the first step is the collection of a consistent data base for the required economic variables. As it is desired to model both the demand for and the supply of telecommunications services, the data base necessarily includes prices, consumption expenditures, population, income levels, production level, labor, capital, R&D expenditures, wages, revenue, profits and costs.

The second step is the fitting of the variables to structural equations and the estimation of some of these equations by a least squares technique. The estimated equations include the basic demand and supply relationships while the other equations (identities) serve for accounting purposes. An example of an identity is revenue equals price times quantity.

The third step is to project certain variables (population, GNP, inflation) that will be used as the basis of the model, by a simple growth pattern. These variables (exogenous) are used to solve the system of simultaneous equations for the unknown (endogenous) variables such as demand, production and prices.

The fourth step is to evaluate the sensitivity of the endogenous variables to changes in the growth pattern of the exogenous variables. One such analysis would examine the effect on demand of steady 10 percent inflation versus steady 5 percent inflation.

## Approach

- Collect historical data
  - Prices of telecommunications services
  - Expenditures for telecommunications services
  - Production levels
  - R&D expenditures
  - Income levels
- Determine relationships in data (least squares)
  - Demand versus price
  - Demand versus income
  - Production versus R&D expenditures
  - Price versus R&D expenditures
- Project baseline growth trends in data
- Sensitivity analysis to:
  - Changes in R&D expenditures
  - Changes in the prices for telecommunications services
  - Changes in income levels

## Database Exogenous Variables

The data for the model was collected annually for the postwar period of 1947-1975 from several sources including:

- Survey of Current Business,
- National Income and Product Account of the U.S. 1929-1965,
- Statistics of Communications Common Carriers,
- Statistical Abstract of the U.S., and
- Employment and Earnings U.S. 1909-1975.

In order to avoid misleading results due to inflation effects, the base year of 1972 was used for both price and dollar figures. That is to say that the dollar figures are in 1972 dollars and that all prices are normalized so that their value in 1972 is 1.0.

The exogenous variables listed are the variables that are considered to be "known" to the model. Sensitivity analyses can be performed by altering the growth trend projection of these variables, and observing the changes in the results of the prediction of the unknown (endogenous) variables. One example would be to double the projection of R&D expenditures and to observe the changes in production, capital, labor, prices and consumption.

### Database Exogenous Variables

- Gross national product (Y)
- Gross national product price index (PY)
- Disposable personal income (Y1)
- Gross domestic product of corporate business (Y2)
- Telecommunications R&D expenditures (D)
- Population (N)
- Telecommunications employee compensation rate (w)
- Telecommunications price of capital stock (r)
- Telecommunications rate of return to capital (s)
- Telecommunications rate of indirect business taxes on gross profit (tx)
- Telecommunications capital retirement rate (d)
- Telecommunications employee separation rate (m)

### Database Endogenous Variables

The endogenous variables are the variables which are predicted using the simultaneous equations model of economic interactions based on designated values for the exogenous variables. The variables fall into three categories:

- 1) Demand variables:  $P_1, P_2, Q_1, Q_2$
- 2) Supply variables:  $Q, P, K, L$
- 2) Identity variables:  $R, C, \pi, I, M$

## Database Endogenous Variables

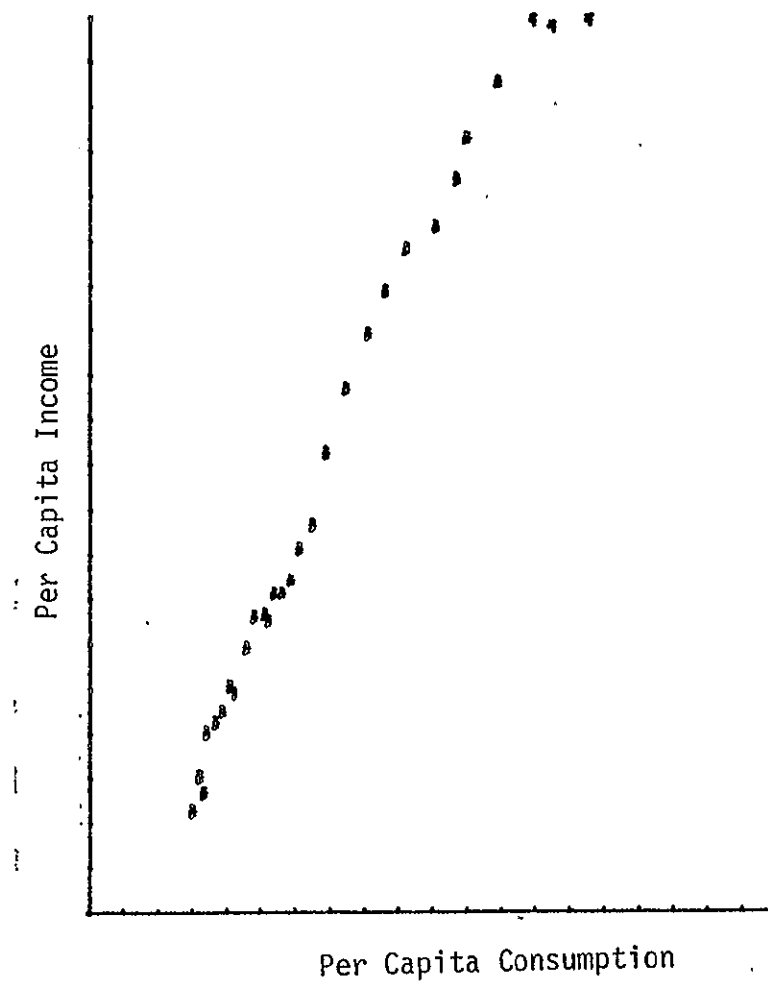
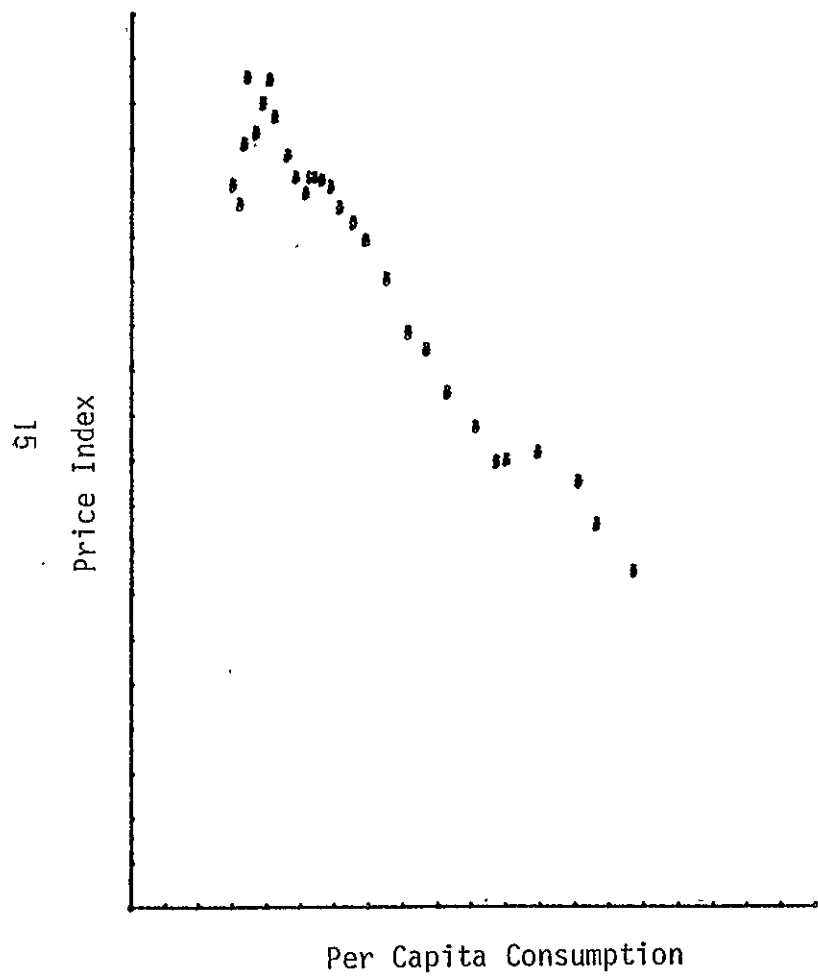
- Telecommunications consumption expenditures
  - Total for personal consumption (Q1)
  - Business and government (Q2)
  - Total (Q)
- Telecommunications price indexes
  - Individual consumer (P1)
  - Business and government (P2)
  - Aggregate (P)
- Telecommunications revenue (R)
- Telecommunications production/cost (C)
- Telecommunications gross profit ( $\pi$ )
- Telecommunications accumulated capital (K)
- Telecommunications full time equivalent employees (L)
- Telecommunications gross investment (I)
- Telecommunications new employment (M)



### Historical Demand Relationships - Personal Consumption

From the historical data base, two plots were made which illustrate the two-variable relationship of demand to prices and demand to income for personal telecommunications expenditures. The axes values are not included since the purpose of the plots is to show the general trend and not the magnitude. Both plots have the expected relationships: 1) higher prices imply lower consumption, and 2) higher income implies higher consumption.

Although these simple illustrations show strong trends in the data, care should be taken not to interpret these plots as complete in themselves since in each only one variable is used as an explanation of consumption expenditures. Only when the interaction of prices, income, and previous consumption patterns are considered, can the actual importance of each variable be determined.

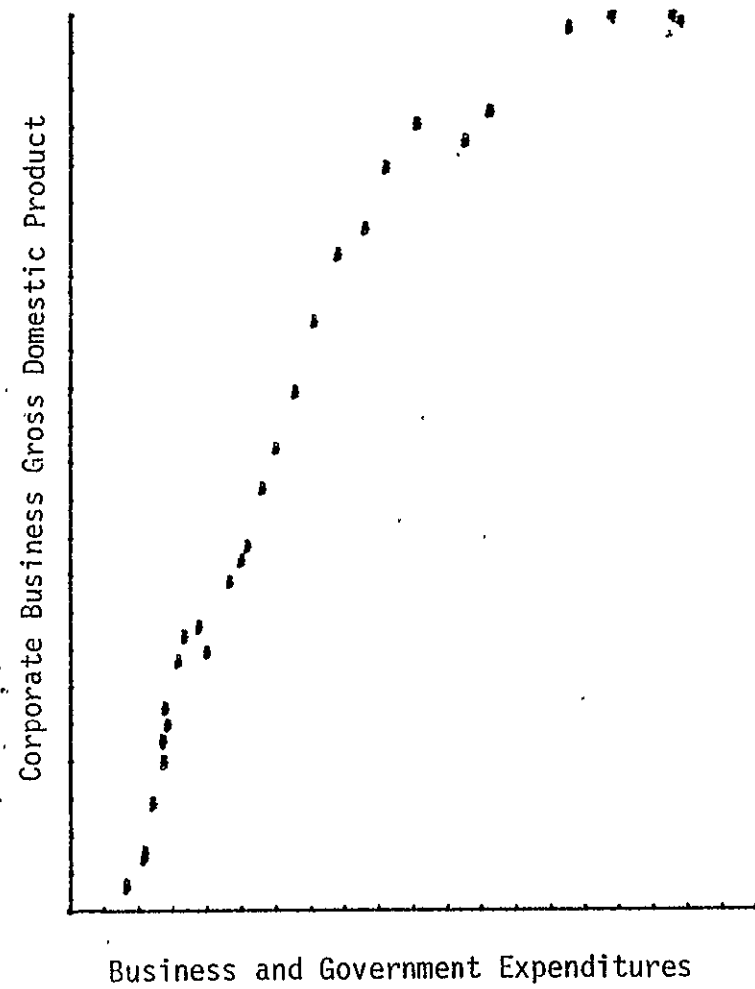
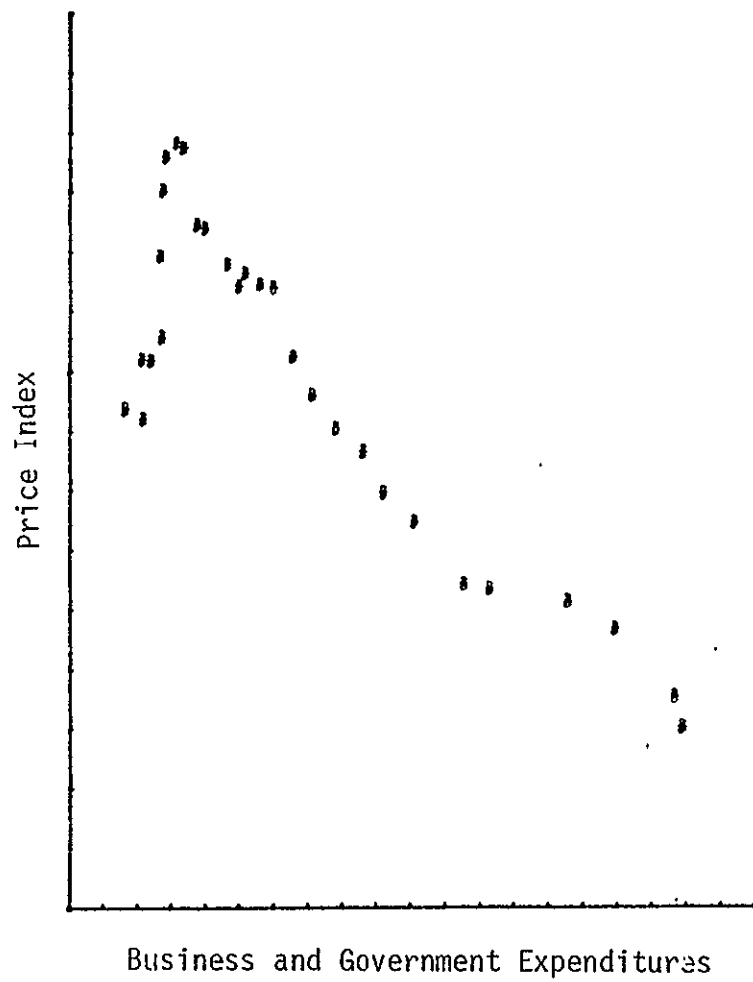


Historical Demand Relationships - Personal Consumption

## Historical Demand Relationships - Business and Government

From the historical data base, two plots were made which illustrate the two-variable relationships of demand to prices and demand to income for business and government telecommunications expenditures. The overall trend in each plot is similar to those for the personal consumption expenditures; however, these seem to be a less strong relationship as shown in the lack of a clear pattern in the higher price range.

Again, the same cautions should be made regarding the use of these plots. They are intended only as an illustration of the general relationships between two variables and should not be used for quantitative assessment.



Historical Demand Relationships - Business and Government

### Econometric Model Definition

The econometric model is not a model in a physical sense, but is a set of simultaneous equations which relate the specific interactions among the variables. The equations consist of two types: 1) identities, and 2) estimated structural equations. The identities serve the purpose of data validation and control and they are strictly defined. For example, revenue is equal to the price times the quantity. Another example of an identity is that new employment in a year is the change in total employment plus the number of separations or:

$$M_t = (L_t - L_{t-1}) + m_t L_{t-1}$$

The estimated equations are less straightforward and oftentimes many alternatives must be tested before a final version is reached. For example, the production level is usually determined by the amount of capital, labor and some index of technology such as R&D expenditures. One problem which arises is that the effect of R&D is not usually felt in the year in which the expenditure is made but usually 5-15 years later. Thus, it is necessary to choose an equation form which recognizes this fact.

### Econometric Model Definition

- System of simultaneous equations relating the economic variables

Identities for data validation

Revenue = (number of units bought) (cost per unit)

$$R = Q \cdot P$$

Equations estimated by least squares

Production depends upon labor, capital, and R&D expenditures

$$Q = f(L, K, D)$$

## Estimated Structural Equation Formulation

The structural equations presented in the final version of the model are the result of the comparison of several alternatives. The alternatives were selected from econometric theory to be the equations most likely to provide a good explanation of the dependent variable. The process is illustrated for the demand equation for business and government telecommunications expenditures.

The first step is to specify the variables from the data base that are likely to participate in the explanation of the business and government expenditures. The two variables selected were business and government telecommunications prices and gross corporate product (income).

The second step is to define the general relationship in the variables, that is, to identify the independent and dependent variables.

The third step is to specify alternative equation structures from the available data in a manner which predicts the change in demand by the changes in the independent variables, while equation (3) predicts the level of demand by the previous periods demand and the "average" price and income levels.

The fourth step is to estimate the equations using a least squares technique and to choose the one which best conforms to a priori expectations. The equation selected (4) predicts the change in demand using the changes in the "average" prices and income.

## Example of Estimated Structural Equation Formulation

- Define Variables

Q2: Business and government telecommunications expenditures

Y2: Gross domestic product of corporate businesses

P2: Telecommunications price index for business and government

PY: GNP Price Deflator

- Define General Relationship

$$Q2_t = f\left(Q2_{t-1}, Y2_t, \frac{P2_t}{PY_t}\right)$$

- Specify Alternative Structures

$$(1) \quad Q2_t = a_0 + a_1 Q2_{t-1} + a_2 Y2_t + a_3 \left(\frac{P2_t}{PY_t}\right)$$

$$(2) \quad (Q2_t - Q2_{t-1}) = b_0 + b_1 (Q2_{t-1} - Q2_{t-2}) + b_2 (Y2_t - Y2_{t-1}) \\ + b_3 \left(\frac{P2_t}{PY_t} - \frac{P2_{t-1}}{PY_{t-1}}\right)$$

$$(3) \quad Q2_t = c_0 + c_1 Q2_{t-1} + c_2 \left(\frac{Y2_t + Y2_{t-1}}{2}\right) + c_3 \left(\frac{\frac{P2_t}{PY_t} + \frac{P2_{t-1}}{PY_{t-1}}}{2}\right)$$

$$(4) \quad (Q2_t - Q2_{t-1}) = d_0 + d_1 (Q2_{t-1} - Q2_{t-2})$$

$$+ d_2 \left(\left(\frac{Y2_t + Y2_{t-1}}{2}\right) - \left(\frac{Y2_{t-1} + Y2_{t-2}}{2}\right)\right) + d_3 \left(\left(\frac{\frac{P2_t}{PY_t} + \frac{P2_{t-1}}{PY_{t-1}}}{2}\right) - \left(\frac{\frac{P2_{t-1}}{PY_{t-1}} + \frac{P2_{t-2}}{PY_{t-2}}}{2}\right)\right)$$

- Estimate All Alternatives and Select "Best"

$$(4) \quad d_0 = .00066, d_1 = .4320, d_2 = .00662, d_3 = -.01328$$



### Estimated Demand Equation Variables

The personal consumption expenditures equation relates the per-capita expenditures to prices and income. The usage of a per-capita measure for both expenditures and for disposable income eliminates the change in the total level that is strictly due to the change in population. The telecommunications price index is compared to the GNP price index to show the change in telecommunications prices relative to overall inflation.

The business and government expenditures equation uses the same structure as the personal consumption expenditures; however, the absolute levels for expenditures and income are used since an appropriate "per-capita" is not available.

### Estimated Demand Equation Variables

- Per capita personal telecommunications expenditure equation
  - Total personal telecommunications expenditures
  - Population
  - Total personal disposable income
  - Telecommunications price index for personal expenditures
  - GNP price index (measure of inflation)
- Business and government telecommunications expenditure equation
  - Total business and government telecommunications expenditures
  - Gross national product
  - Gross domestic product of corporate businesses
  - Telecommunications price index for business and government expenditures
  - GNP price index (measure of inflation)

## Supply Equation Variables

The choice of the variables to be used in the estimated supply equations was made in a manner consistent with economic theory, data availability and the defined purpose of this model.

As previously discussed, the production level is usually considered to be determined by the amount of capital and labor, and the level of technology. As there is no simple measure of technology, the R&D expenditures were chosen to represent the increased efficiency associated with better technology.

The labor equation predicts the number of full-time equivalent telecommunications employees. The variables chosen represent the major factors in changes in the work force, for example, higher production implies higher labor requirements and higher R&D expenditures implies more efficiency, which means lower labor requirements.

The capital equation predicts the total accumulated capital in telecommunications. Similar relationships are expected to appear in the capital and labor equations with respect to R&D and production. Furthermore, if the price of capital stock increases more quickly than the telecommunications price index, capital will look relatively more expensive and the amount of capital will go down.

## Estimated Supply Equation Variables

- Telecommunications production equation
  - Total telecommunications production
  - Fulltime equivalent telecommunications employees
  - Total accumulated capital in telecommunications
  - R&D expenditures in telecommunications
- Telecommunications labor equation
  - Full time equivalent telecommunications employees
  - Telecommunications employee compensation rate
  - Telecommunications aggregate price index
  - R&D expenditures in telecommunications
  - Total telecommunications production
- Telecommunications capital equation
  - Total accumulated capital in telecommunications
  - Price of telecommunications capital stock
  - Telecommunications aggregate price index
  - R&D expenditures in telecommunications

### Econometric Model Identity Definition

The remaining eight equations in the model are identities, that is, they are not estimated but they define strict relationships in the data. Some examples are, the total production  $Q$  is the sum of personal and business and government expenditures,  $Q_1$  and  $Q_2$  respectively, the aggregate price index  $P$ , is the weighted average of the price indexes for personal consumption and for business and government,  $P_1$  and  $P_2$  respectively, and revenue,  $R$ , is equal to the price  $P$ , times the quantity  $Q$ .

### Econometric Model Identity Definition

$$Q_t = Q1_t + Q2_t$$

$$P_t = \left( \frac{Q1_t}{Q_t} \right) P1_t + \left( \frac{Q2_t}{Q_t} \right) P2_t$$

$$R_t = P_t Q_t$$

$$C_t = r_t K_t + w_t L_t$$

$$\pi_t = \left( \frac{S}{1 - tx} \right) P_{yt} K_t$$

$$P_t = \left( \frac{C_t + \pi_t}{Q_t} \right)$$

$$I_t = K_t - (1-d_t)K_{t-1}$$

$$M_t = L_t - (1-m_t)L_{t-1}$$

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### Demand Equation Identity Variables

- Total telecommunications expenditures equation
  - Total telecommunications expenditures
  - Total personal telecommunications expenditures
  - Business and government telecommunications expenditures
- Telecommunications aggregate price index equation
  - Telecommunications aggregate price index
  - Total telecommunications expenditures
  - Total personal telecommunications expenditures
  - Business and government telecommunications expenditures
  - Telecommunications price index for personal expenditures
  - Telecommunications price index for business and government expenditures

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## Supply Equation Identities Variables

- Telecommunications production cost equation

Telecommunications production cost  
Fulltime equivalent telecommunications employees  
Telecommunications employee compensation rate  
Total accumulated capital in telecommunications  
Price of telecommunications capital stock

- Telecommunications gross profit equation

Telecommunications gross profit  
Total accumulated capital in telecommunications  
GNP price deflator  
Telecommunications rate of indirect business taxes on gross profit  
Telecommunications rate of return to capital

- Telecommunications aggregate price index equation

Telecommunications aggregate price index  
Telecommunications production cost  
Telecommunications gross profit  
Total telecommunications production

- Telecommunications revenue equation

Total telecommunications revenue  
Telecommunications aggregate price index  
Total telecommunications production

## Database Usage of Identities

In certain cases the desired data was not readily available from standard sources and some of the variables had to be created. In most instances, the identities were used when the data for all but one variable in an identity could be collected. A simple example is that there was not a figure for business and government expenditures on telecommunications so the difference between the total figure and the personal consumption figure was used.

The following is a less straightforward example: since there was not a series for the price index for business and government, the only identity which used the price index was examined and it was determined that data was available for five of the six variables. Thus, the business and government price index was computed using the relationship

$$P_2 = \left( P - \left( \frac{Q_1}{Q} \right) P_1 \right) \left( \frac{Q}{Q_2} \right)$$

or

$$P_2 = \frac{PQ - P_1 \cdot Q_1}{Q_2}$$

## Database Usage of Identities

### Example 1:

Collect total telecommunications consumption expenditures (Q)  
Collect personal telecommunications expenditures (Q1)  
Subtract Q1 from Q to get business and government expenditures

$$Q2 = Q - Q1$$

### Example 2:

Collect total telecommunications consumption expenditures (Q)  
Collect personal telecommunications consumption expenditures (Q1)  
Collect business and government telecommunications consumption expenditures (Q2)  
Collect telecommunications aggregate price index (P)  
Collect price index for personal telecommunications expenditures (P1)  
Using identity

$$P = \left( \frac{Q1}{Q} \right) P1 + \left( \frac{Q2}{Q} \right) P2$$

Compute business and government price index (P2)

$$P2 = \left( P - \left( \frac{Q1}{Q} \right) P1 \right) \left( \frac{Q}{Q2} \right)$$

### Model Estimation Demand Equations

The final form of the demand equations predicts the change in demand as a function of the change in the demand of the previous period, the change in the average income and the change in the average prices.

Care should be taken in looking at the coefficients in the two equations. The magnitudes of the coefficients are not directly comparable due to the relative magnitudes of all of the variables. For example, the two price coefficients,  $-.0133$  and  $-2.44$ , are virtually identical when the relative magnitudes of all variables are considered.

The most important observation from these equations is the signs of the price and income coefficients. In both equations, the sign of the income variable is positive meaning that an increase in income yields an increase in demand. In both equations, the sign of the price variable is negative meaning that an increase in prices yields a decrease in demand.

Another observation is that the level of change in demand for the current period is explained by the level of change in demand of the previous period by 43 percent in the personal expenditures equation and by 37 percent in the business and government expenditures equations indicating the "habit-forming" effect of telecommunications expenditures.

## Model Estimation Demand Equations

$$\begin{aligned} \left( \frac{Q1_t}{N_t} - \frac{Q1_{t-1}}{N_{t-1}} \right) &= .00066 + .432 \left( \frac{Q_{t-1}}{N_{t-1}} - \frac{Q_{t-2}}{N_{t-2}} \right) + .0066 \left( \left( \frac{Y1_t}{N_t} + \frac{Y1_{t-1}}{N_{t-1}} \right) - \left( \frac{Y1_{t-1}}{N_{t-1}} + \frac{Y1_{t-2}}{N_{t-2}} \right) \right) \\ &\quad - .0133 \left( \left( \frac{P1_t}{Py_t} + \frac{P1_{t-1}}{Py_{t-1}} \right) - \left( \frac{P1_{t-1}}{Py_{t-1}} + \frac{P1_{t-2}}{Py_{t-2}} \right) \right) \end{aligned}$$

$$\begin{aligned} (Q2_t - Q2_{t-1}) &= .0806 + .365 (Q2_{t-1} - Q2_{t-2}) - .0137 \left( \left( \frac{Y2_t}{2} + \frac{Y2_{t-1}}{2} \right) + \left( \frac{Y2_{t-1}}{2} - \frac{Y2_{t-2}}{2} \right) \right) \\ &\quad - 2.44 \left( \left( \frac{P2_t}{Py_t} + \frac{P2_{t-1}}{Py_{t-1}} \right) - \left( \frac{P2_{t-1}}{Py_{t-1}} + \frac{P2_{t-2}}{Py_{t-2}} \right) \right) \end{aligned}$$

### Model Estimation Supply Equations

The supply equations are less straightforward in appearance; however, the direction of the changes is quite obvious. The major difference between the supply equations and the demand equations is that the supply equations are expressed in log-linear (Cobb-Douglas) form, while the demand equations are simply linear.

The first equation shows the production function using labor, capital and R&D expenditures as the independent variables. It should be noted that there is a positive coefficient on the R&D variable  $\ln(D_{t-1})$  which means that higher R&D implies higher production levels.

The second equation shows the labor relationship to prices, wages, production and R&D. A major portion (81.5 percent) of the labor level of the previous period explains the current labor level. It can be seen that more R&D (which implies more efficiency) causes the labor requirement to go down as does the wage rate relative to current telecommunications prices. As expected higher production levels mean higher labor requirements.

The third equation shows the relationship of capital to prices, cost of capital, production and R&D. The relationships which appear here are similar to those in the labor equation.

# Model Estimation Supply Equations

$$\ln \left( \frac{Q_t}{Q_{t-1}} \right) = .022 + .024 \ln(D_{t-1}) + .925 \ln \left( \frac{K_t}{K_{t-1}} \right) + .203 \ln \left( \frac{L_t}{L_{t-1}} \right) \\ + .042 \left( .730 \ln(K_{t-1}) + .501 \ln(L_{t-1}) - \ln(Q_{t-1}) \right)$$

$$\ln(L_t) = -.223 + .815 \ln(L_{t-1}) - .189 \ln(D_{t-1}) - .743 \ln \left( \frac{\left( \frac{W_t}{P_t} \right)}{\left( \frac{W_{t-1}}{P_{t-1}} \right)} \right) - .327 \ln \left( \frac{W_{t-1}}{P_{t-1}} \right) \\ + .950 \ln \left( \frac{Q_t}{Q_{t-1}} \right) + .413 \ln(Q_{t-1})$$

$$\ln(K_t) = .380 + .616 \ln(K_{t-1}) - .028 \ln(D_{t-1}) - .080 \ln \left( \frac{r_{t-1}}{P_{t-1}} \right) \\ + .383 \ln \left( \frac{Q_t}{Q_{t-1}} \right) + .377 \ln(Q_{t-1})$$



## Econometric Model Elasticities

Since a direct comparison of the coefficients in the previous equations is impossible due to the different magnitude of the variables, a standardized method of comparison is necessary to determine the relative importance of the independent variables. The most common method is to use a sensitivity coefficient called an elasticity which measures the percentage change in the dependent variable resulting from a percentage change in one of the independent variables holding all other independent variables constant. These elasticities can be formed for the short run, that is the effect this year of a change in this year, or for the long run, that is the accumulated effect over future years of a change in this year.

Elasticities can be used to describe the effect of factors on both demand and supply. On the demand side, the price elasticity is the percentage change in spending patterns due to a percentage change in prices. For the supply side, an example is the effect of R&D spending on the production level.

## Econometric Model Elasticities

- Short run elasticity

  - Immediate effect to change

  - Effect of changes in very recent years

- Long run elasticity

  - Accumulated long term effect of change

  - Effect of changes in many following years

- Demand elasticities

  - Effect of price changes on telecommunications expenditures

  - Effect of income level changes on telecommunications expenditures

- Supply elasticities

  - Effect of R&D expenditures on production

  - Effect of R&D expenditures on prices

## Demand Elasticities

The demand elasticities measure the percentage change in demand caused by a percentage change in either prices or income.

As expected, higher prices imply lower demand (negative elasticity), but more importantly the relationship is less than one to one. Over the short term, a 10 percent increase in prices will cause only a 2 percent decrease in expenditures which means that the demand is insensitive (or inelastic) to price changes. The long term price effect is also inelastic and the private consumer reacts slightly more to prices than does business and government.

Again as expected, higher income implies higher demand (positive elasticity). For personal consumption expenditures the short term income elasticity is low (.28), while the long run elasticity is nearly one (.99) implying that, over the long run, a 10 percent increase in personal disposable income will cause a 10 percent increase in personal telecommunications expenditures. For business and government the short term income effect is still inelastic (.48) although more elastic than the personal expenditures elasticity. The long term income effect for business and government (1.53) is elastic meaning that there is a 15 percent response in demand to every 10 percent change in income.

Demand Elasticities				
	Price		Income	
	Short Term	Long Term	Short Term	Long Term
Personal	-.23	-.81	.28	.99
Business and Government	-.24	-.77	.48	1.53

## Supply Elasticities

The supply elasticities illustrated show the effect of a percentage change in R&D expenditures, holding everything else constant, on production, labor and capital. The price elasticity is the effect of R&D expenditures on the aggregate price of telecommunications services and is implied by the production, labor and capital elasticities.

The signs of the elasticities tell us that an increase in R&D expenditures cause an increase in production, a decrease in the labor requirement, a decrease in the capital requirement and a decrease in prices. The short term elasticity of R&D expenditures is very small since there is a lag in the time it takes for R&D spending to filter into the system.

The major long term effect (which is approximately one to one) of R&D expenditures is decreasing the labor requirement which implies more efficient operation. The production level rises 5.6 percent with a 10 percent increase in R&D expenditures. The smallest effect of R&D is on the total accumulated capital which is very inelastic to changes in R&D.

The first order price elasticities show that price is very inelastic ( $-.125$ ) to R&D in the short run and relatively inelastic ( $-.701$ ) to R&D in the long run.

Supply Elasticities		
R&D Expenditures		
	Short term (one year)	Long term
Production	.02369	.5579
Labor	-.18864	-1.0194
Capital	-.02835	-.07376
Price (implied by above elasticities)	-.1250	-.7014

### Projection of Total Demand

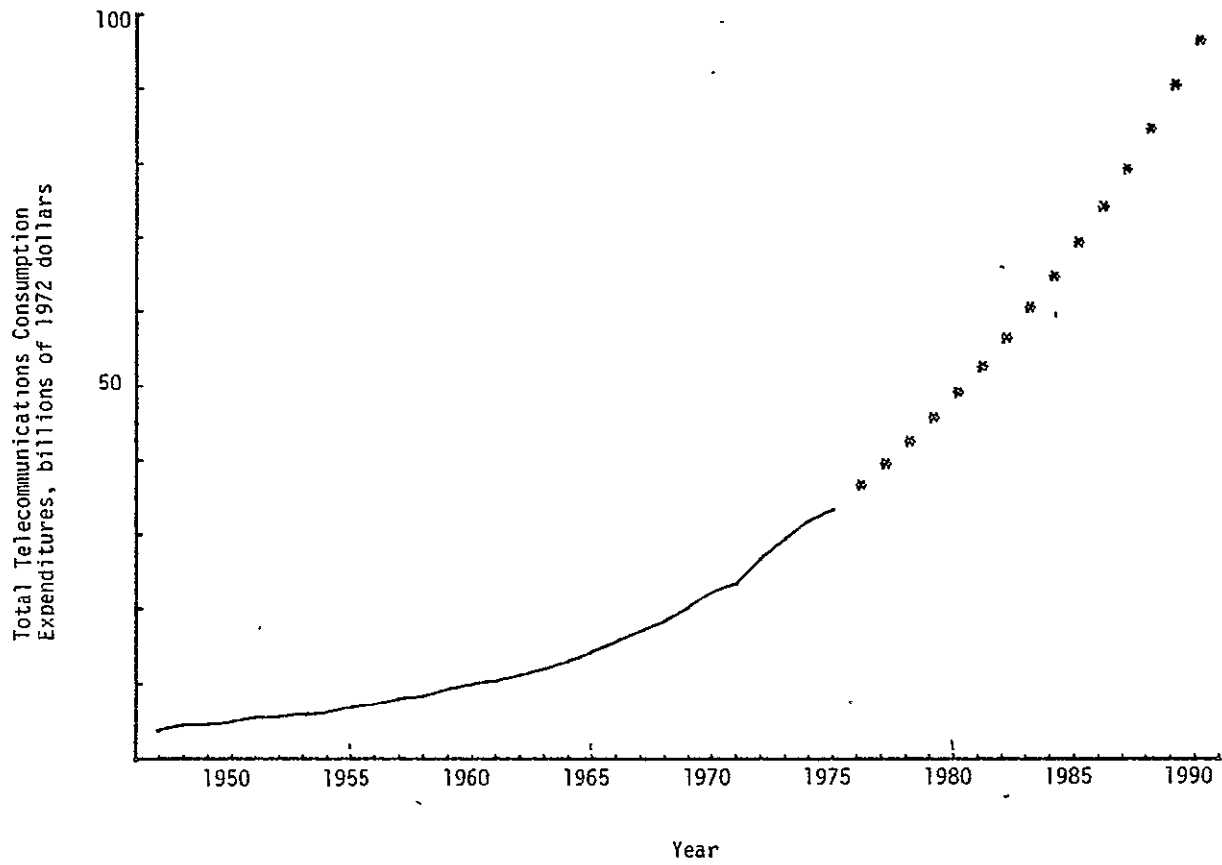
A projection was made of the total telecommunications demand under the condition that all trends remain the same for variables such as labor, capital, prices, population. The form of projection is

$$Q_t = -59.78 + .0307 t + 1.054 Q_{t-1}$$

and

$$Q_{1975} = \$33.49 \text{ billion}$$

The projected value for 1990 is  $Q_{1990} = \$95.94 \text{ billion}$ .



Baseline Projection: Total Demand



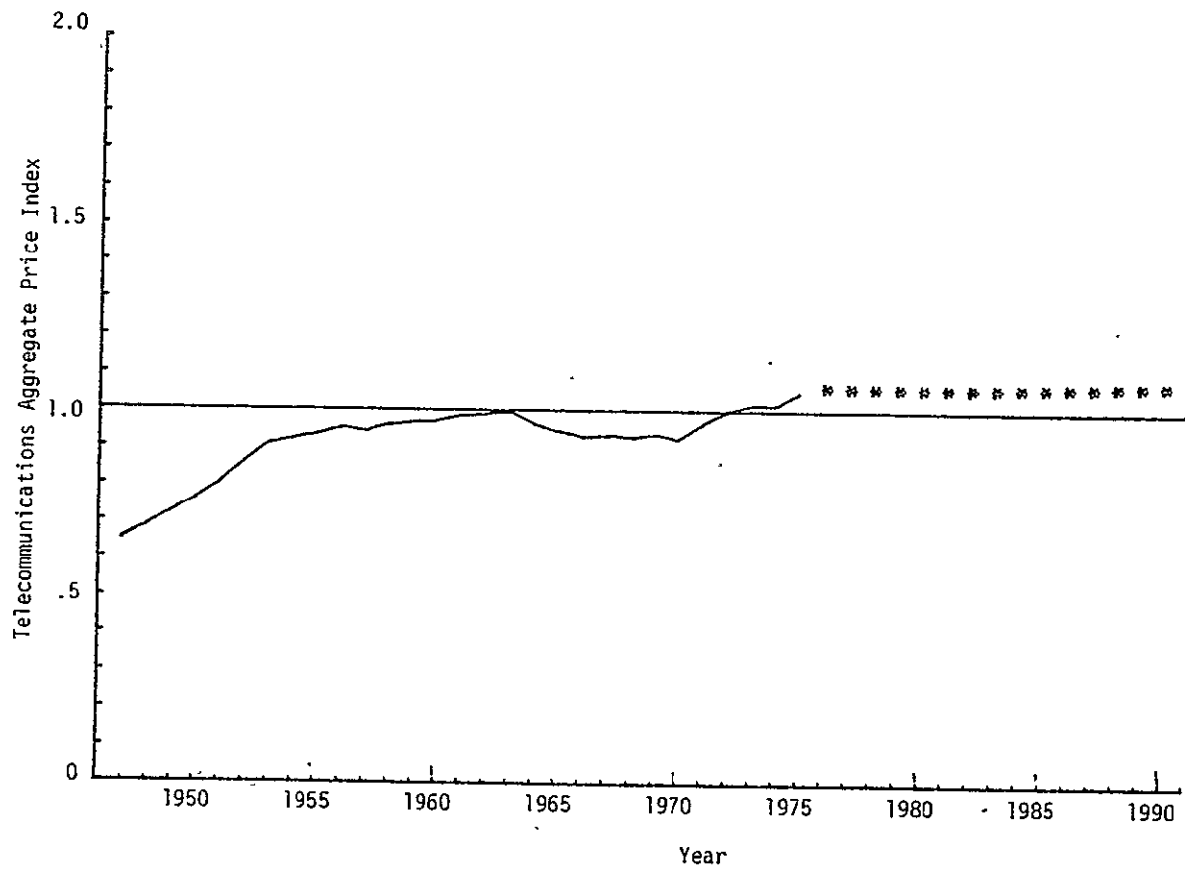
### Projection of Aggregate Price Index

A projection was made of the telecommunication aggregate price index under the condition that all trends remain the same. The form of the projection is

$$P_t = .4757 + .00032t + .8482 P_{t-1}$$

$$P_{1975} = 1.051$$

$$P_{1990} = 1.058$$



Baseline Projection: Aggregate Price Index

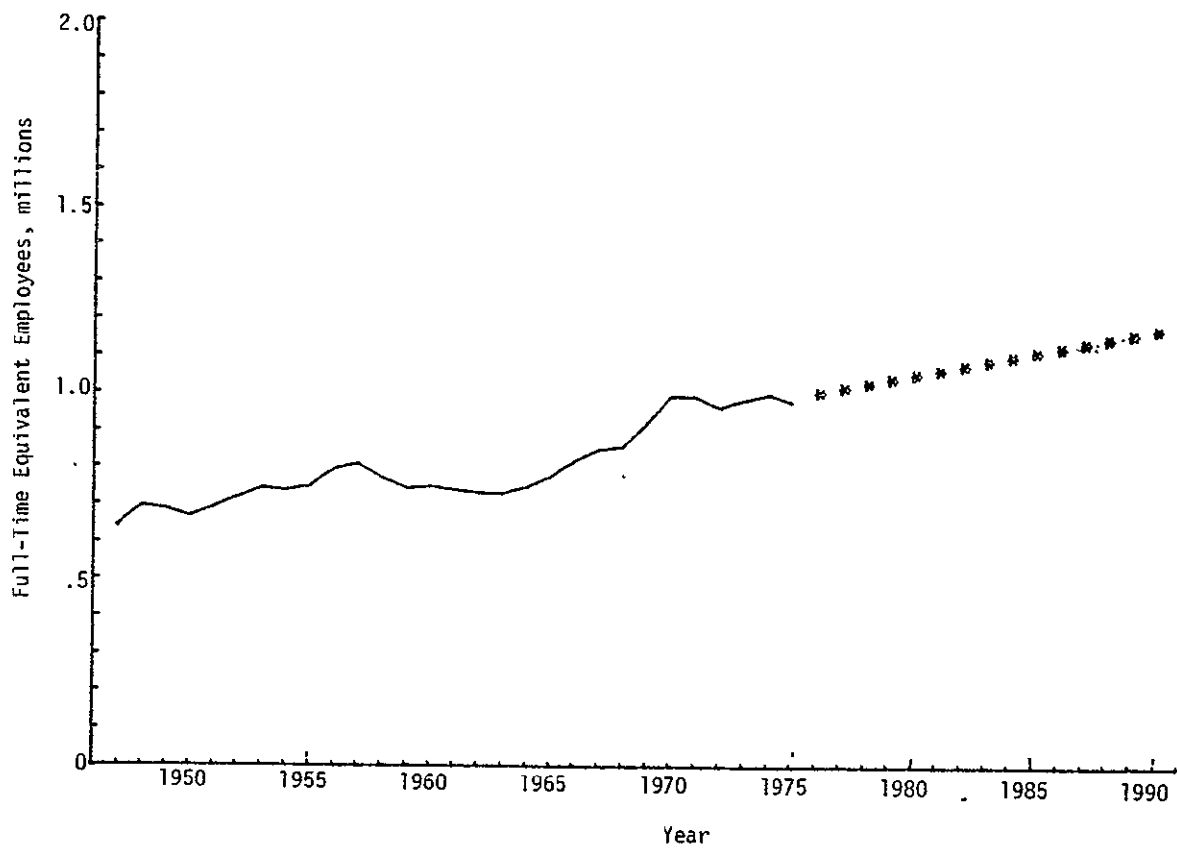
### Projection of Labor

A projection was made of the number of full-time equivalent employees in the telecommunications industry under the condition that all trends remain the same. The form of the projection is

$$L_t = -3.558 + .00189t + .8472 L_{t-1}$$

$$L_{1975} = .978 \text{ million}$$

$$L_{1990} = 1.158 \text{ million}$$



Baseline Projection: Labor

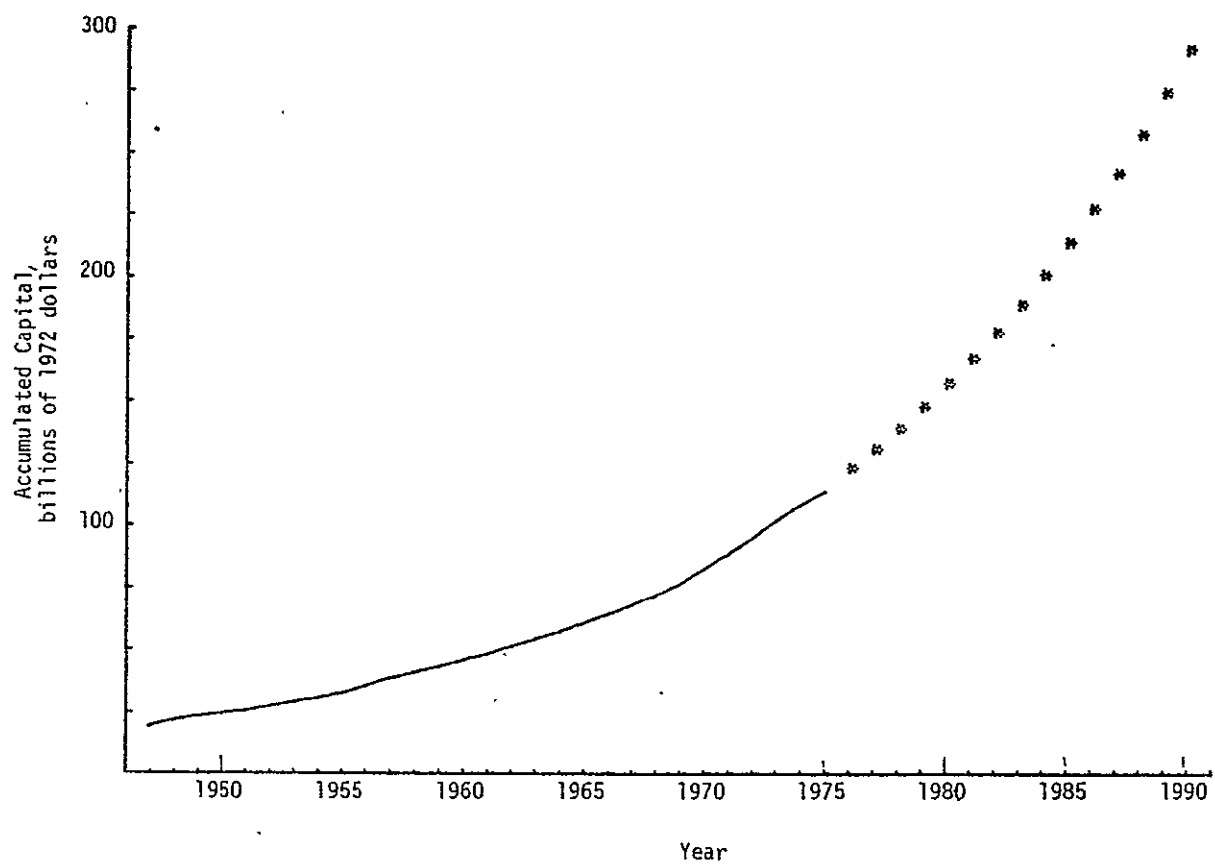
### Projection of Accumulated Capital

A projection was made of the total accumulated capital in the telecommunications industry under the condition that all trends remain the same. The form of the projection is

$$K_t = 24.58 - .0126t + 1.067 K_{t-1}$$

$$K_{1975} = \$113.5 \text{ billion}$$

$$K_{1990} = \$289.8 \text{ billion}$$



Baseline Projection: Capital

## Summary

The major points in the study are summarized on the facing page and are resultant from the equation estimation and the calculation of elasticities. The real power of an econometric model lies in the user's ability to ask "what if" type of questions such as "what if the population stabilized in 1980 at 225 million?" or "what if R&D expenditures were tripled?" The general trends can be inferred from the estimated equations; however, the interrelationships among all of the equations is too complex to allow for an immediate quantitative answer to the above questions. The completion of the econometric model simulation is the only way in which these questions can be quantitatively observed.

## SUMMARY

### Historical Demand

Short-term demand is insensitive to changes in income and prices

Long-Term demand is insensitive to price changes

Income more important than prices

Individuals react less to income than business and government

### Historical Supply

R&D expenditures lower capital and labor requirements

R&D expenditures raise productivity

Major long-term effect of R&D is on labor requirement

Accumulated capital insensitive to R&D



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ESTIMATION OF  
THE DEMAND FOR  
MEDICAL COMMUNICATIONS  
SERVICES

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## Medical Care Services

Medical communications services would improve emergency medical services, teleconsultation, remote patient care (telediagnosis), supervision of allied health care workers, administration, and management of health care resources.

Multiple simultaneous terminals, two-way audio/video, slow scan TV, data transfer and facsimile transmission are the service types needed.\*

The benefits to the general public would include reducing the inefficiencies of an already over-burdened health care system, and providing good health care accessibility for rural areas by reducing the required number of physicians, by substitution of a system combining physicians, medical technicians, and a telecommunication network.

The fundamental assumption which underlies the estimation of the demand for medical communications services in the U.S., is that a particular communications satellite service is most applicable to thinly populated areas due to:\*\*

- Concentrations of services which have developed in densely populated areas.
- Concentrations of communications accompany the concentrations of services.
- Large scale demand is the driving force in development of such concentrations.
- Satisfaction of the demand is economically practicable by terrestrial means where large scale demand exists in concentrated form.
- Thinly populated areas do not normally develop large scale demand.
- Concentrations of services and associated communications do not normally occur in thinly populated areas.
- Substitution may be required in thinly populated areas for services which are readily available in urbanized areas.
- Communications satellites are particularly effective in delivering services to a large area, whereas terrestrial techniques are more effective in delivery services to points or small areas.
- Communications satellites are likely to be more effective in delivery of services to large, thinly populated areas than are terrestrial techniques; they may be able to supplement terrestrial techniques in densely populated areas, by providing in them more services already being provided to thinly populated areas.

---

\* Public Service Communications Satellite Workshop, Easton, Maryland, 1976.

\*\* Report of Task Force B, Broadcasting Service Group on Satellite Broadcasting (BSG/SAT), "Functional User Requirements".

### Medical Care Services

Objective: Provide means for delivery of medical care to remote areas by linking a physician at a medical center to the community physicians, nurse or technician

Rationale: Spiraling costs, increasing demands for greater services, more effective and efficient administration and application of current medical techniques

Service Applications: Doctors (Specialists)  
Documentation  
Transportation  
Hospital Services

### Thinly Populated States

By analyzing the Standard Metropolitan Statistical Areas (SMSA), 25 thinly populated states (TPS) were identified. Included among these are primarily western and southern states. No Mid-Atlantic or East North Central states were included.

## Thinly Populated States

### Included

- Mountain States
- Pacific States (except Calif.)
- West North Central States (except Iowa)
- West South Central States (except Louisiana)

No Mid-Atlantic or East North Central States were included.

## Physician Availability

The TPS exhibit similar characteristics with respect to available medical services which differ from the U.S. norm. The national average of physicians is 182 per 100,000 population; the average in the TPS is 134 per 100,000 population. With the exception of Colorado and Vermont all of the TPS fall below the U.S. national average. (Note that Colorado and Vermont are therefore excluded from all further discussion and calculations.) If each of the 23 states were to be brought up to the current national average (182 per 100,000 population), a total of 23,228 physicians would be required.\*

---

\* Note that if each TPS were to have 182 physicians per 100,000 population, the National Average would shift upward. This shift has not been considered in the following calculations.

Physician Availability				
Thinly Populated State	Physicians per 100,000 Population	Deviation from national average of 182/1000	Population in thousands	Physicians needed to reach national average 182/100,000
Wyoming	110	-72	353	254
New Mexico	136	-46	1106	509
Idaho	102	-80	770	616
Montana	118	-64	721	461
Arizona	178	-4	2058	82
Nevada	127	-55	548	301
Utah	158	-24	1157	278
Colorado*	194	+12		--
Alaska	130	-52	330	172
Oregon	164	-18	2225	401
Washington	178	-4	3429	137
South Dakota	89	-93	685	637
North Dakota	105	-77	640	493
Kansas	133	-49	2279	1117
Nebraska	128	-54	1542	833
Minnesota	168	-14	3897	546
Oklahoma	114	-68	2613	1777
Missouri	142	-40	4757	1903
Mississippi	99	-83	2281	1893
Kentucky	118	-64	3342	2139
South Carolina	114	-68	2726	1854
Arkansas	118	-64	2037	1307
Texas	140	-42	11794	4953
Vermont*	190	+8		--
Maine	127	-55	1028	565
Total			52318	23228
* Above the national average of 182 physicians per 100,000 population.				



## Telemedicine Substitutability

The average salary for a physician in the United States is \$50,000 per year. On average a doctor sees 125.8 patients per week.\* The average time the physician spends with a patient is 13 minutes per visit.\*\* In a year (50 weeks), the average doctor spends 1,363 hours with patients during 6,290 separate visits per year. It is assumed that the need for one doctor is equivalent to the demand for 6,290 visits or 1,363 patient hours. The cost for this physician service would be \$37 per hour. Therefore, the price to the user for telemedicine must be less than \$37 per hour for the services to be demanded. This might be possible if through the use of a communications network and paramedical services, the time of the physicians and particularly the specialists can be used more efficiently. For example, a doctor normally spends a substantial percentage of his patient time with patients whose ailments do not require a doctor. Therefore, a doctor's time in these situations where diagnosis is not a problem can be substituted with the time of a paramedic (at a much lower salary) and a communications network to link that paramedic to the physician for only the time necessary for diagnosis which the paramedic is incapable of performing. If this combination can be produced at a cost below the cost of the doctor, it is assumed that there will be a demand for the service. The price referred to throughout is the price per hour of such a system (including paramedic service, communications network and the cost of the consulting time of the physician as required).

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\* Profile of the Medical Practice, AMA, 1976.

\*\* "A Preliminary Evaluation of Alternative Communications Systems for the Relay of Primary Health Care to Remote Areas," 1975.

### Telemedicine Substitutability

125.8	Patients per physician per week (average)
<u>x 50</u>	weeks per year
6,290	patients per physician per year
<u>x 13</u>	minutes
81,770	patient minutes per physician per year
=	1,363 patient hours per physician per year

<u>\$50,000</u>	per physician salary per year (average)
1,363	patient hours per physician per year
=	\$37 per hour physician's patient time

### Additional Population Served

At the current level of physicians per 100,000 population in the TPS there is an assumed lack of medical service, i.e., it is assumed that the current national average (182 physicians/100,000 population) indicates a national average demanded medical coverage. Therefore, if a state has only 75 percent of the current national average physicians per population, it lacks 25 percent of the national average demanded medical service. Even though it is not strictly the case, this is roughly equivalent to 25 percent of the population being unserved. That is, in terms of a rough order of magnitude of total service, it does not matter if each of the state's inhabitants lack 25 percent of the adequate service level or if 75 percent of the population is serviced and 25 percent has no service. This rough equivalent of lacking service in terms of population unserved is presented in the following table.

Additional Population to be Served				
State	Population, 100,000 persons	Patient Hours Required, 1000 per year	Patient Visits Required, millions per year	Additional Population to be Served, 100,000 persons
Wyoming	3.53	346	1.60	1.4
New Mexico	11.06	694	3.20	2.8
Idaho	7.70	840	3.87	3.4
Montana	7.21	628	2.90	2.5
Arizona	20.58	112	.52	.4
Nevada	5.48	410	1.89	1.6
Utah	11.57	379	1.75	1.5
Alaska	3.30	234	1.08	1.0
Oregon	22.25	547	2.52	2.2
Washington	34.29	187	.86	.7
South Dakota	6.85	868	4.01	3.5
North Dakota	6.40	672	3.10	2.7
Kansas	22.79	1522	7.03	6.2
Nebraska	15.42	1135	5.24	4.6
Minnesota	38.97	744	3.43	3.1
Oklahoma	26.13	2422	11.18	10.0
Missouri	47.57	2594	11.97	10.5
Mississippi	22.81	2580	11.91	10.5
Kentucky	33.42	2915	13.45	11.7
South Carolina	27.26	2527	11.66	10.1
Arkansas	20.37	1781	8.22	7.1
Texas	117.94	6751	31.15	27.1
Maine	10.28	770	3.55	3.1
Total	523.18			127.7

## States' Willingness to Pay for Medical Services

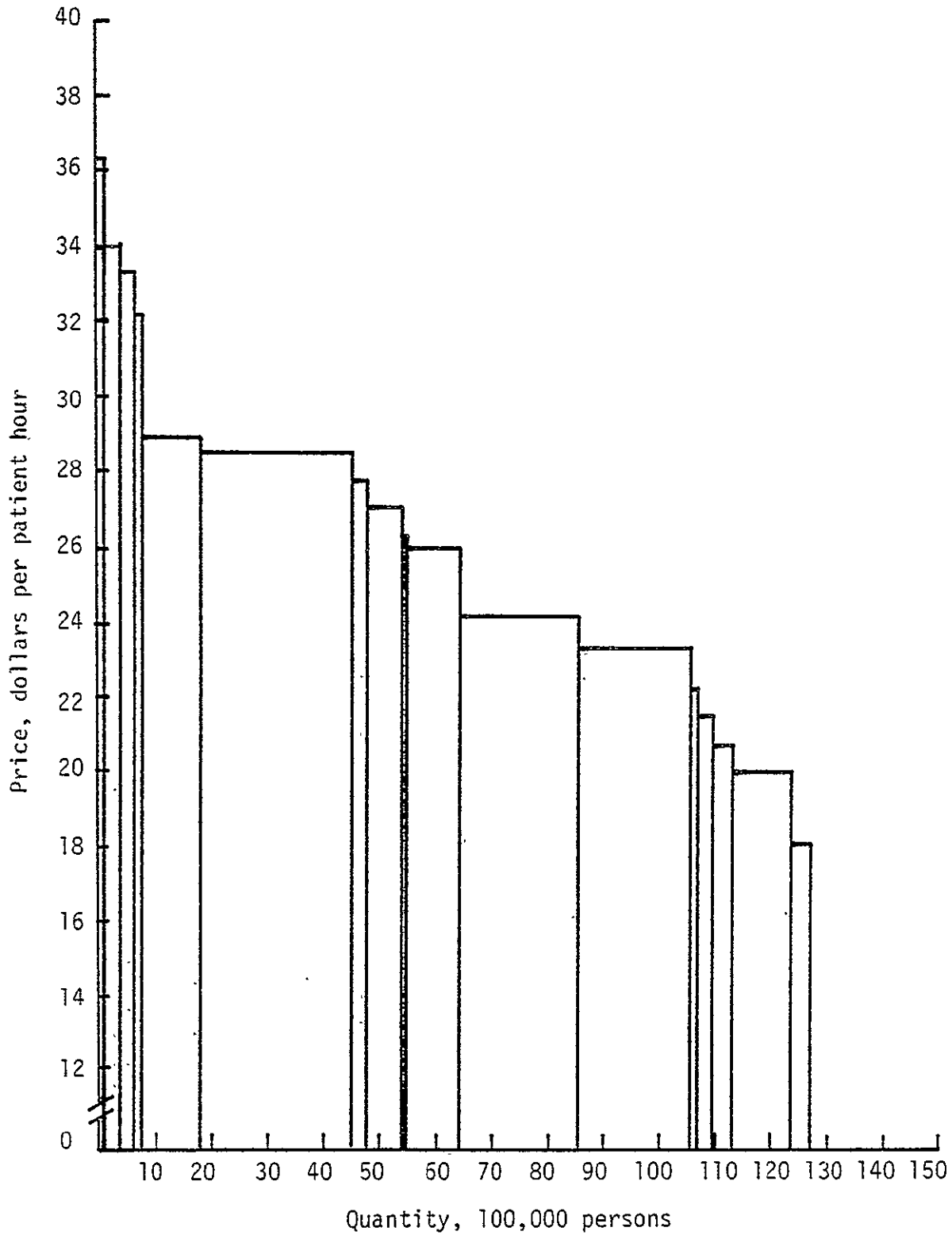
It has been assumed that the percentage of the U.S. physician/population ratio for a given state is related to that state's ability to financially support additional health services. It is assumed that this percentage is an indicator as to the responsiveness which the state population would have toward supporting an increase in their health care availability. Therefore, the percentage of the current physician-population rates has been applied to the cost of supporting the number of additional physicians needed. Thus, it is the willingness of the population to support the additional telemedicine services as a substitute for on-site physicians at various prices which defines the demand curve. The indicated acceptable price per hour is the fraction of \$37 per hour which a state is willing to pay. If a patient hour could be supplied at this price (a specific fraction of \$37 per hour) the state could be brought up to the current national average (182/100,000) of physicians at the expenditure it is willing to pay. The resultant price per hour applied to the population of the state yields the total expenditures by the state. The following table and histogram illustrates these calculations. Note that in the TPS an expenditure of, for instance, 60 percent of the cost of the needed physicians will not necessarily hire 60 percent of the number of the physicians required because of the population is spread out and the expenditure necessary to hire one physician may not be affordable in a geographic area which one physician can reasonably serve. Also note that the demand takes the form of a histogram because the quantities (patient hours required, channels, etc.) have been aggregated to the state level and the state as a whole enters the market at a certain price in a "demand block."

States' Willingness to Pay for Medical Services

State	Percentage of National Average Physicians/ 100,000 Population*	Indicated Acceptable Price, dollars per hour	Indicated Acceptable Price, dollars per hour
Wyoming	60	22.2	7.6
New Mexico	75	27.8	19.1
Idaho	56	20.7	17.2
Montana	65	24.1	15.0
Arizona	98	36.3	4.0
Nevada	70	25.9	10.5
Utah	87	32.2	12.1
Alaska	71	26.3	6.1
Oregon	90	33.3	18.0
Washington	98	36.3	6.7
South Dakota	49	18.1	15.6
North Dakota	58	21.5	14.3
Kansas	73	27.0	40.8
Nebraska	70	25.9	29.2
Minnesota	92	34.0	25.1
Oklahoma	63	23.3	56.0
Missouri	78	28.9	74.2
Mississippi	54	20.0	51.1
*Kentucky	65	24.1	69.5
South Carolina	63	23.3	58.4
Arkansas	65	24.1	42.5
Texas	77	28.5	190.7
Maine	70	25.9	19.8

\*  $\frac{\text{Physicians/100,000 in state}}{\text{Physicians/100,000 in U.S.}}$

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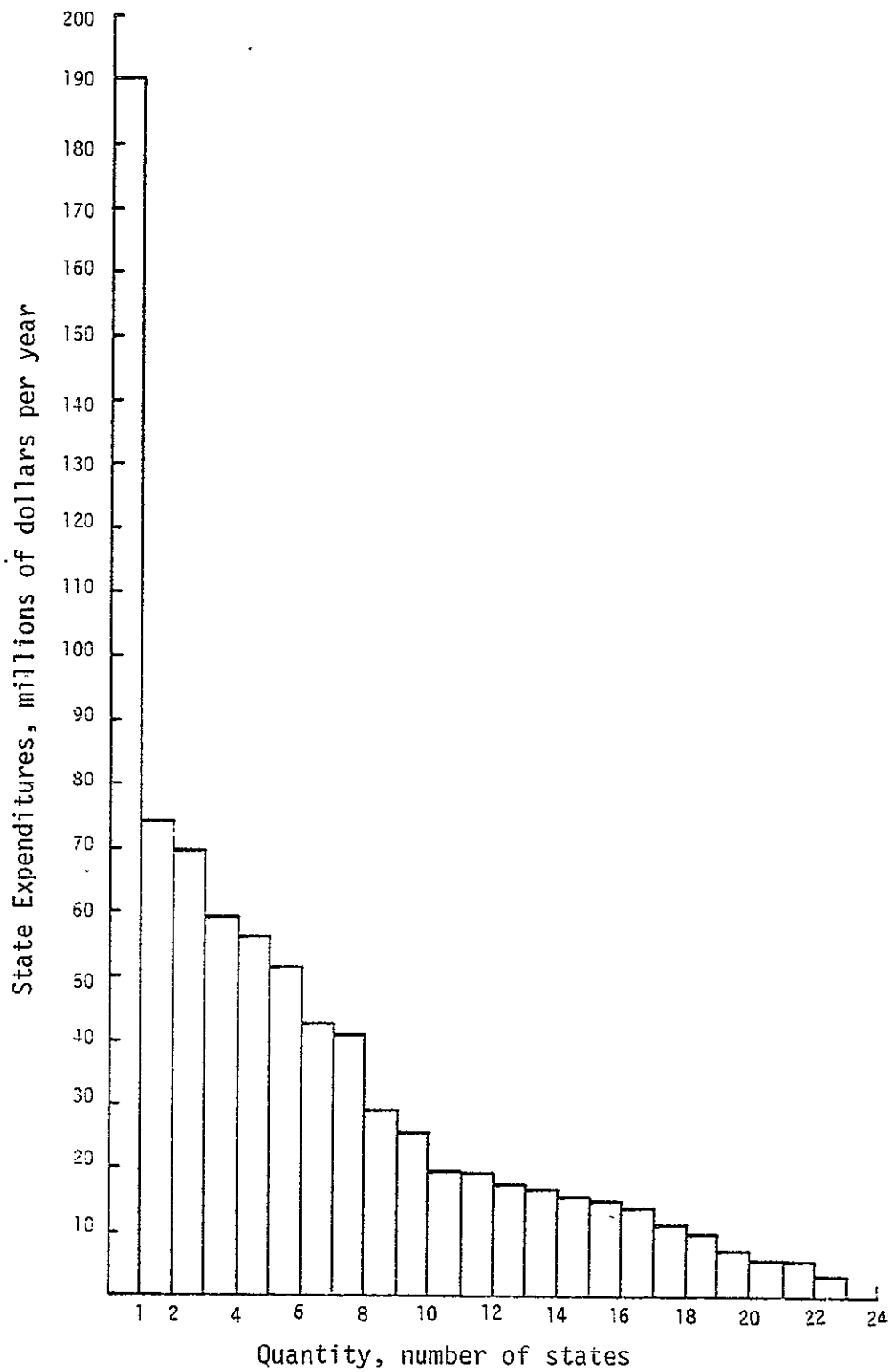


Additional Population Served by Medical Telecommunications Service

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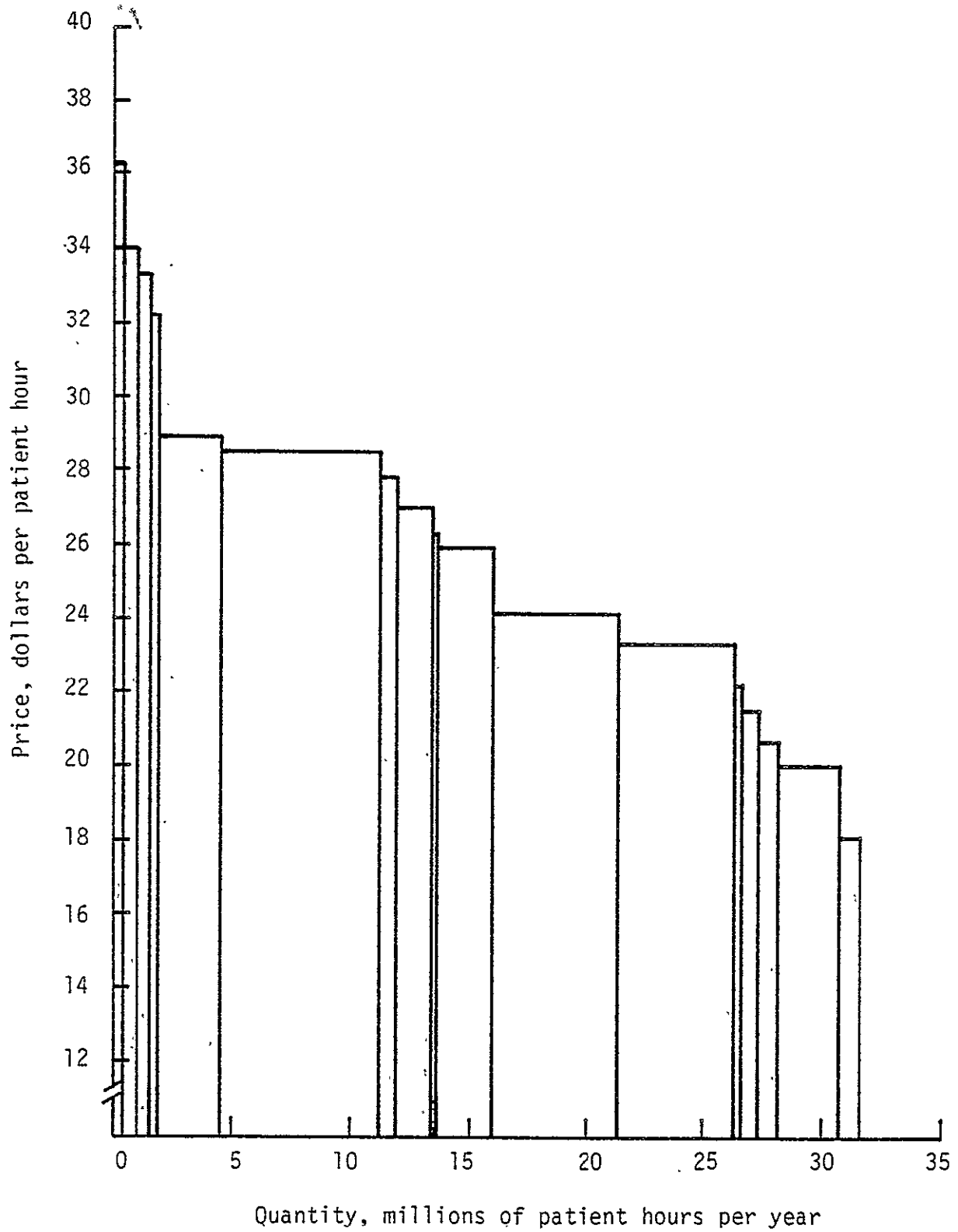
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Total Expenditures Affordable by States

### Patient Hours Demanded to Bring TPS up to National Average

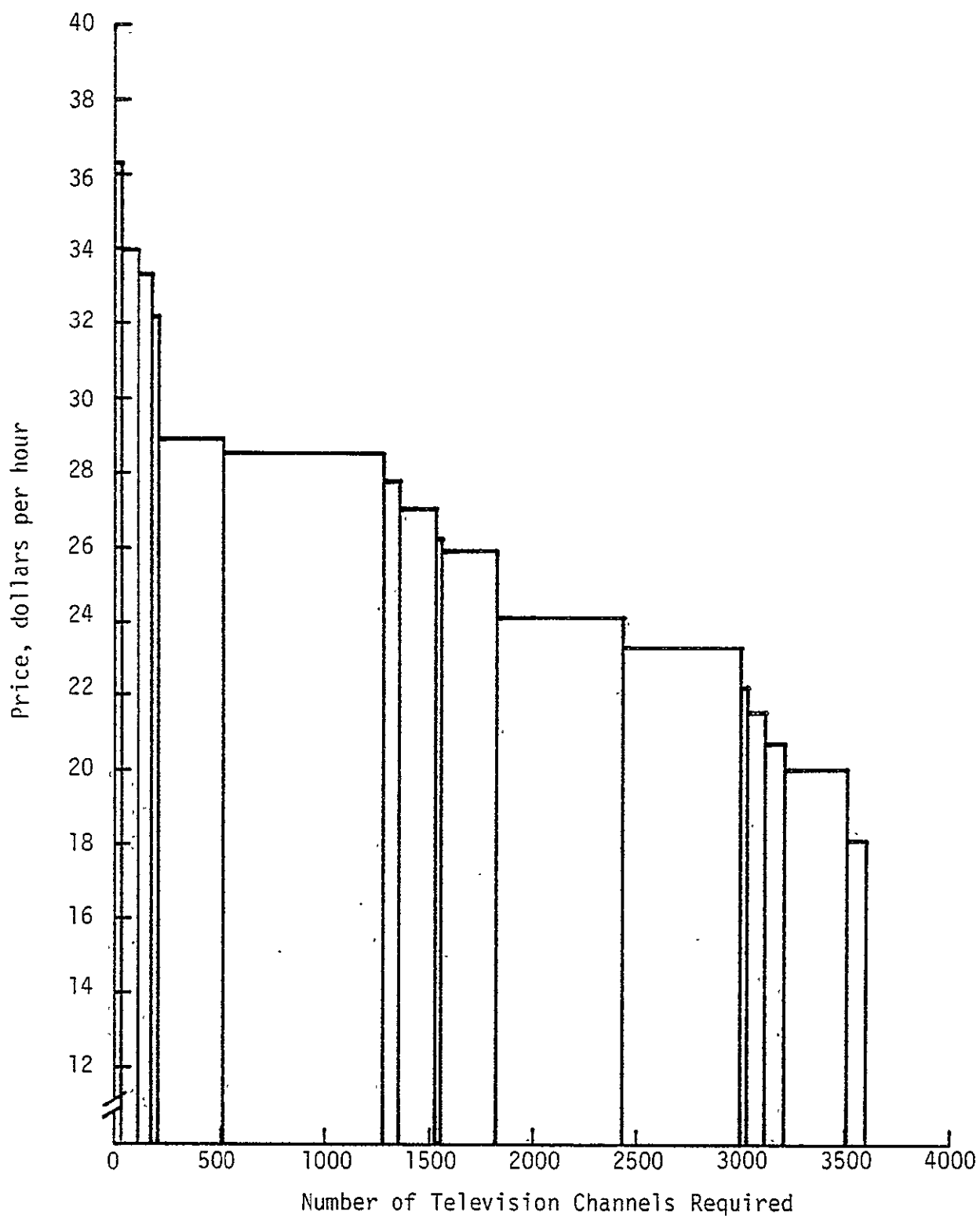
This demand can then be transformed into the number of patient visits or number of patient hours demanded by using the assumption stated earlier of an average of 6,290 visits or 1,363 patient hours per doctor required.



Patient Hours Demanded to Bring TPS up to Current National Average

### Demand for Medical Telecommunication Services Expressed in Terms of Channel Requirements

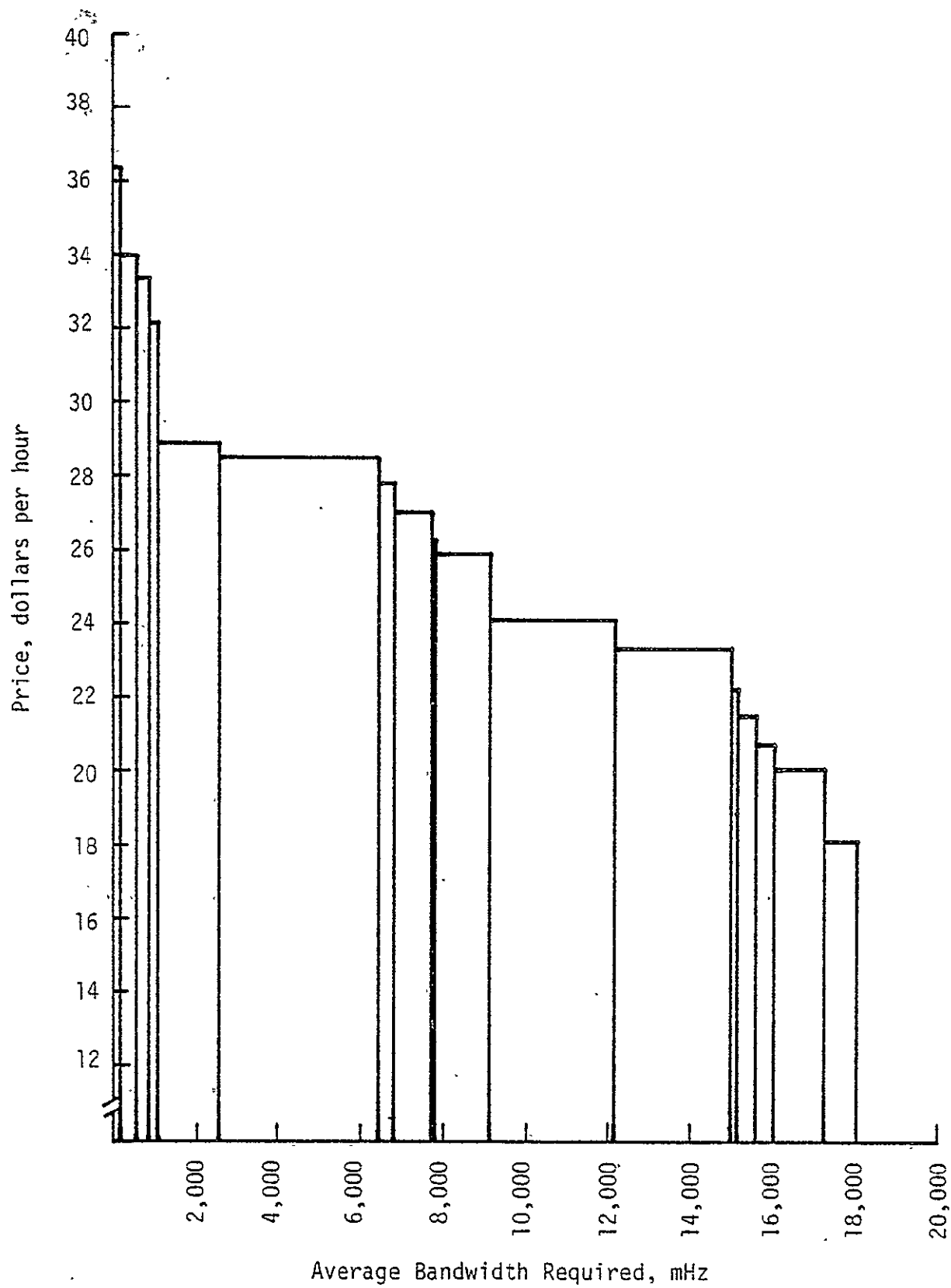
It is assumed that the service will be available on at least an emergency basis 365 days a year and 24 hours per day. The required patient hours at this usage level provide the average channel requirements. Since there will be peak and slack times there will be a peak to average load utilization factor. This situation has not been analyzed in this study.



Demand for Medical Telecommunication Services  
Expressed in Terms of Channel Requirements

Demand for Medical Telecommunication Services  
Expressed in Terms of Bandwidth

It is assumed that two-way audio/video communications will be used. This does not, however, require simultaneous two-way communications. Therefore, approximately 5 MHz per channel is required. The demand in terms of average bandwidth required is illustrated.



Demand for Medical Telecommunication Services  
Expressed in Terms of Bandwidth



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## Conclusions

1. The 23 identified thinly populated states are potential users of telecommunications as a medical service alternative.
2. Approximately 23,000 additional physicians would be required in these states to attain the national physician/population average ratio (182/100,000).
3. If the thinly populated states would be willing to pay a specific percentage of the cost of hiring physicians, and if the cost per patient hour were this percentage of the cost of a physician, they could be brought up to the present national average at the expenditure that state was willing to pay.
4. At \$36.30 per patient hour 299,000 hours would be demanded while at \$18.10 per patient hour 31.66 million hours would be demanded.
5. This demand implies a requirement for 34 5mHz TV channels at \$36.30 per patient hour and 3,614 channels at \$18.10 per patient hour. This yields an average bandwidth of 171 mHz and 18,070 mHz, respectively.

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ESTIMATION OF  
THE DEMAND FOR  
EDUCATIONAL  
COMMUNICATION  
SERVICES

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## Educational Communications Service\*

Educational telecommunications service involving television, computer-assisted instruction, and information resource sharing are in various stages of planning and implementation across the country. This section outlines the potential capital resources which may be available to an Educational Television (ETV) system and an estimate of the demand for service at various price levels.

Telecommunications has the potential of providing large gains in educational productivity, increasing teaching effectiveness and broadening the availability of education resources.

The primary role of satellites toward the delivery of primary and secondary education media and services would be in the direct delivery to schools, broadcasting stations and district or regional headends for further redistribution. Computer resource availability would be greatly increased and could be applied to interactive computing, remote batch processing, computer interconnection for raw computer time and interlibrary communications.

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\*ORI, Public Service Users Workshop at Easton, Maryland, 1976; R. Morgan, J. Singh; Satellite Utilization for Educational Communications in the U.S., 1973.

## Educational Communications Services

### OBJECTIVES:

- Reduce audio-visual costs
- Reach communities isolated both geographically and by lack of communications facilities
- Share the best educational and informative resources among all communities
- Increase productivity in a labor-intensive social service area

### SERVICES:

- Instructional Television
- Computer-Assisted Instruction
- Computing Resources
  - Multi-Access Interactive Computing
  - Remote Batch Processing
  - Computer Interconnection
- Information Resource Sharing
  - Inter-Library Communication
  - Automated Remote Information Retrieval
  - Teleconferencing

## Educational System And Programming Library\*

The ETV service which is discussed in the following pages is based upon an assumed network which would broadcast instructional television programs to primary and secondary level classrooms. The many computer-assisted instructional functions which are possible are assumed not to be included in the ETV system considered here.

A minimum library of programs will be necessary for an effective ETV system. This library would provide an adequate selection of programs to be used for grade levels K through 12 for subject and grade specific curriculum planning. For the eight elementary grades, four main subjects (language, science, mathematics, social studies) could utilize ETV programs. Individual programs average approximately 20 minutes in length with about 20 percent of the classroom time utilizing some ETV programming during 30 weeks of the 36-week school term. Approximately half of the course programs would be subject related and half would be aimed at specific grades. The total course program library is 600 hours.

It is assumed that 30 courses in secondary grades are adaptable to ETV. Utilizing television on average of 30 hours per course, with half being subject specific and half grade-level oriented, a total of 600 hours programming time is calculated.

---

\* A. Denzau, H. Barrett, Appendix to Future Development of Instructional Television, Washington University, Missouri, 1971.

## Educational System And Programming Library

### Elementary School:

8 grades x 4 subjects = 32 subjects

Assume 20 minutes/program, 3 times/week, 30 weeks therefore  
30 hours/subject

$$1/2(32 \times 30) + 1/2(8 \times 30) = 600 \text{ hours}$$

### Secondary School:

Assume 30 courses adaptable to TV, 3-20 minute programs/week for  
30 weeks

Therefore 30 hours per course

$$1/2(30 \times 30) + 1/2(10 \times 30) = 600 \text{ hours}$$

### Total Programming Time:

$$600 \text{ hours} + 600 \text{ hours} = 1,200 \text{ hours for K through 12}$$



### Availability of Capital\*

The average annual expenditure per pupil in 1975-1976 was \$1,388. Instructional expenditures, from which ETV funding would be derived, accounts for about 9 percent of the total pupil cost.

It seems reasonable to anticipate that 1 to 3 percent of the total annual expenditures might be allocated to ETV, thus yielding approximately \$13.88 to \$41.64 per pupil per year. One to two percent of the pupil expenditures are considered as likely national funding levels. This corresponds to \$13.88 per pupil per year or less than \$.40 per week at 1 percent, and \$27.76 per pupil per year or less than \$.80 per week, at 2 percent.

Eliminating the programming cost for 1,200 hours (at \$1,000/minute) yields a total of \$1,177.2 million available for transmission and reception costs assuming 2 percent and \$552.6 million at 1 percent of the total annual expenditures for pupils being allocated for ETV.

---

\* Digest of Education Statistics, 1975 Edition, DHEW.

### Availability of Capital

1. Average Annual Expenditure per Pupil = \$1,388

1 percent = \$13.88

2 percent = \$27.76

3 percent = \$41.64

2. Potential U.S. Available Capital (C)

45,000,000 students x \$27.76 = \$1,249 million

45,000,000 students x \$13.88 = \$625 million

3. Estimating Cost per Channel Hour:

$$C = C_p + C_T$$

$C_p$  = Cost for programming = 1200 x \$60,000 = \$72 million

$C_T$  = Cost for broadcast transmission and reception

$C - C_p = C_t = \$1,177$  million @ 2 percent

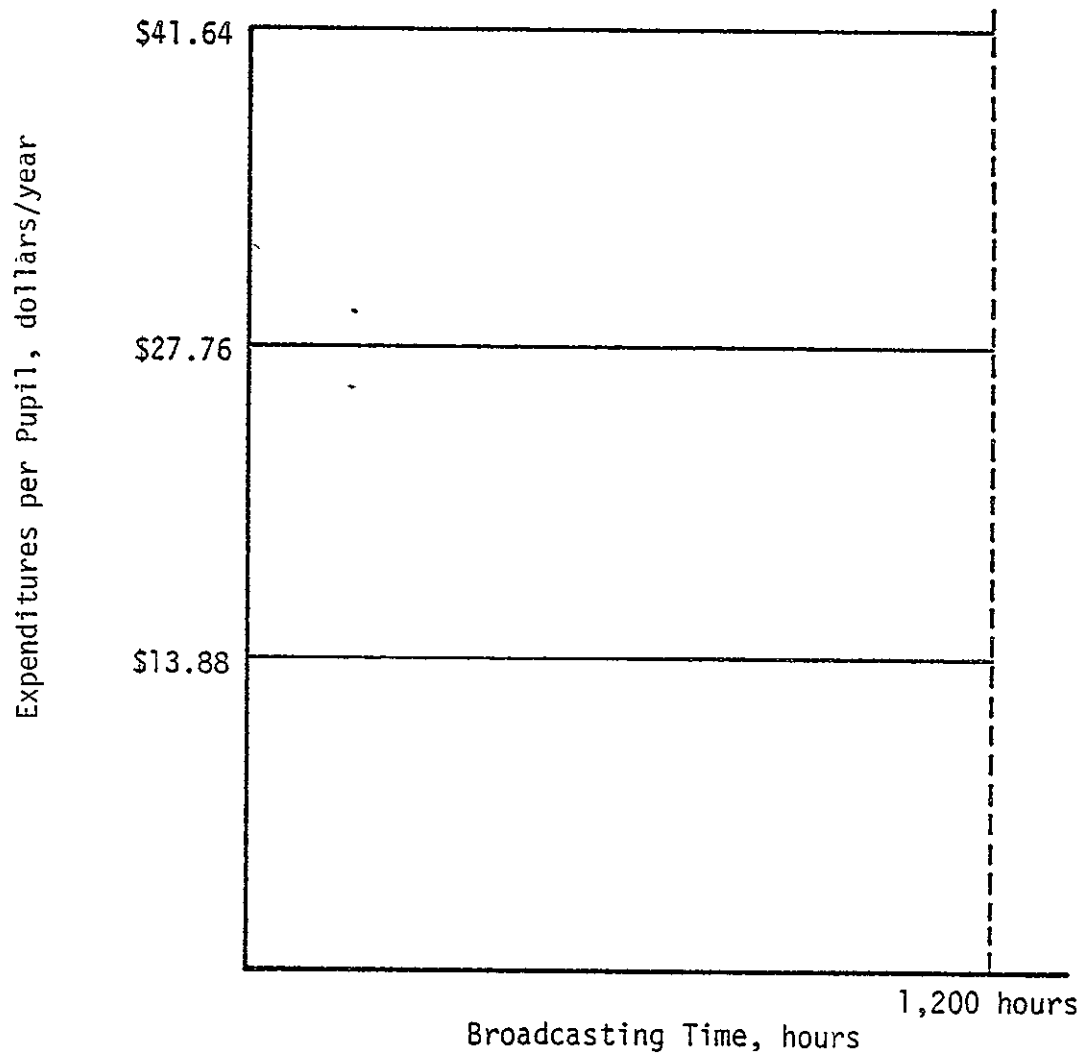
= \$553 million @ 1 percent

## Price-Quantity Relationship for a Program Library

An adequate program library for an ETV service requires a relatively fixed minimum number of program selections. The cost of producing these programs will be a fixed expenditure regardless of the number of students utilizing the system.

The cost of distribution, redistribution, and accessory equipment will, however, be directly related to the serviced student population.

The price-quantity relationship illustrated on the facing page demonstrates that a fixed expenditure will have to be made in a minimum program library regardless of the contribution per pupil utilizing the ETV service.



Broadcasting Time Price-Quantity Relationship

## Availability of Capital in States

Considering 1 to 2 percent of the annual expenditure per pupil as a reasonable allocation of funds for ETV, the accompanying histograms (based upon the table below) illustrate the number of states (including the District of Columbia) which would be capable of supporting an ETV system at various price contributions per student per year.

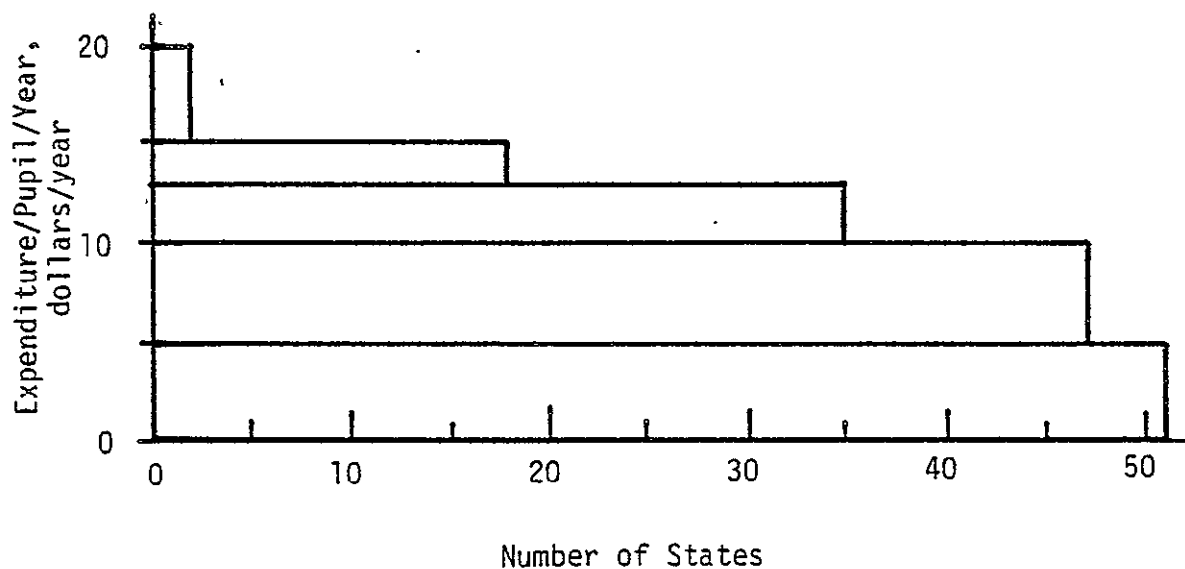
At a cost of \$10 or less per pupil nearly all of the states could afford to participate in the system if 1 percent of the annual student expenditure was allocated for ETV. If 2 percent of the annual student expenditure was allocated to ETV, then all states could afford to utilize ETV if the cost of ETV was \$20 or less per pupil per year.

States' Expenditures\* per Pupil per Year, \$/pupil/year

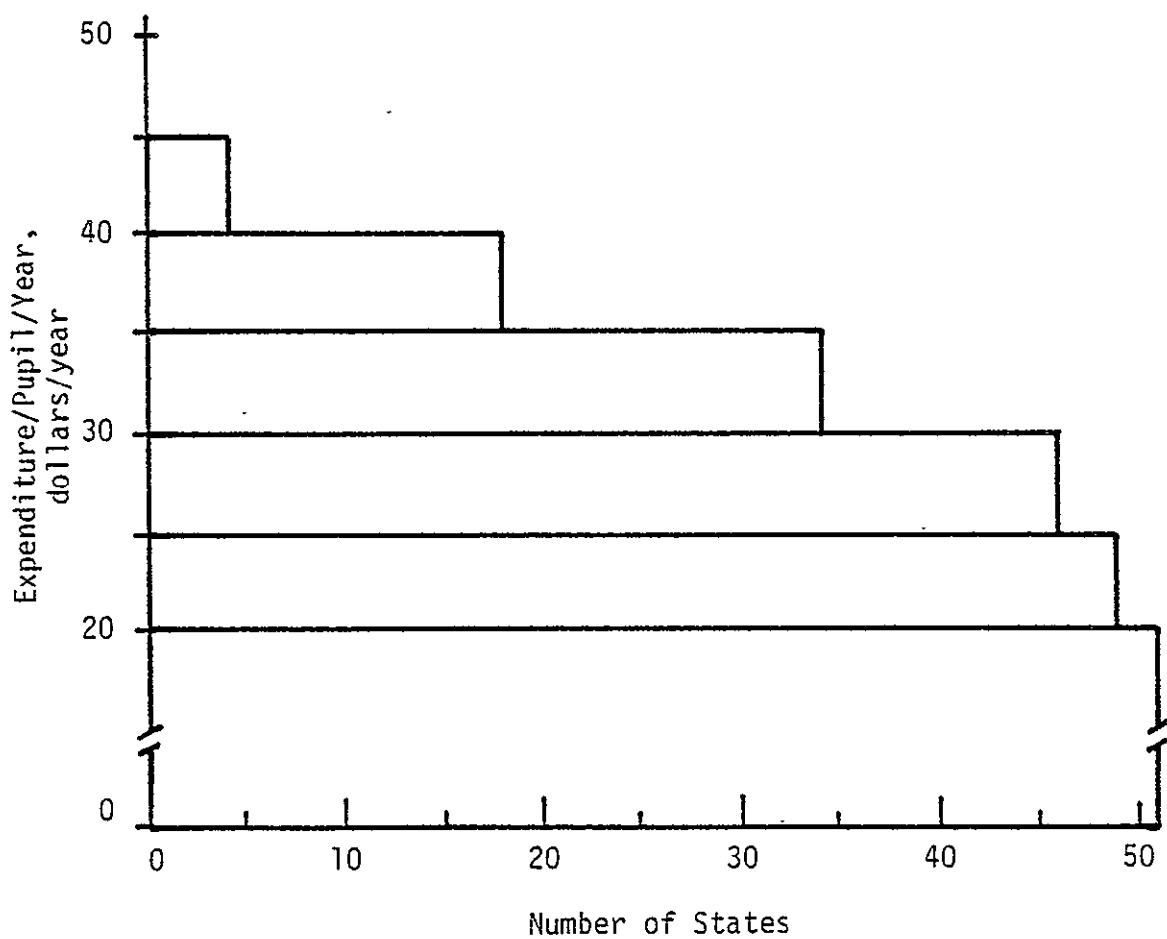
State		% of Expenditures 1% 2%		State		% of Expenditures 1% 2%	
1	Alabama	9.33	18.66	26	Missouri	12.03	24.06
2	Alaska	22.28	44.56	27	Montana	13.92	27.84
3	Arizona	15.46	30.92	28	Nebraska	13.78	27.56
4	Arkansas	10.57	21.74	29	Nevada	13.08	26.16
5	California	13.73	27.46	30	New Hampshire	11.73	23.46
6	Colorado	14.23	28.46	31	New Jersey	17.13	34.26
7	Connecticut	15.96	31.92	32	New Mexico	12.82	25.64
8	Delaware	17.23	34.46	33	New York	22.41	44.82
9	District of Columbia	19.57	39.14	34	North Carolina	11.51	23.02
10	Florida	13.94	27.84	35	North Dakota	11.99	23.98
11	Georgia	10.87	21.74	36	Ohio	12.70	25.40
12	Hawaii	16	32.00	37	Oklahoma	11.31	22.62
13	Idaho	12.32	24.64	38	Oregon	16.42	32.84
14	Illinois	16.37	32.74	39	Pennsylvania	15.87	31.74
15	Indiana	12.98	25.96	40	Rhode Island	16.65	33.30
16	Iowa	14.00	28.00	41	South Carolina	11.25	22.50
17	Kansas	16.07	32.14	42	South Dakota	10.62	21.24
18	Kentucky	9.56	19.12	43	Tennessee	9.97	19.94
19	Louisiana	16.37	32.74	44	Texas	10.73	21.46
20	Maine	11.30	22.60	45	Utah	12.65	25.30
21	Maryland	17.71	35.42	46	Vermont	12.67	25.34
22	Massachusetts	15.04	30.08	47	Virginia	12.31	24.62
23	Michigan	17.70	35.40	48	Washington	13.39	26.78
24	Minnesota	16.35	32.70	49	West Virginia	10.20	20.40
25	Mississippi	9.21	18.42	50	Wisconsin	14.52	29.04
				51	Wyoming	14.01	28.02

\* Digest of Educational Statistics, 1975, DHEW.

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Availability of Capital From States (1% of Total Annual Expenditures)



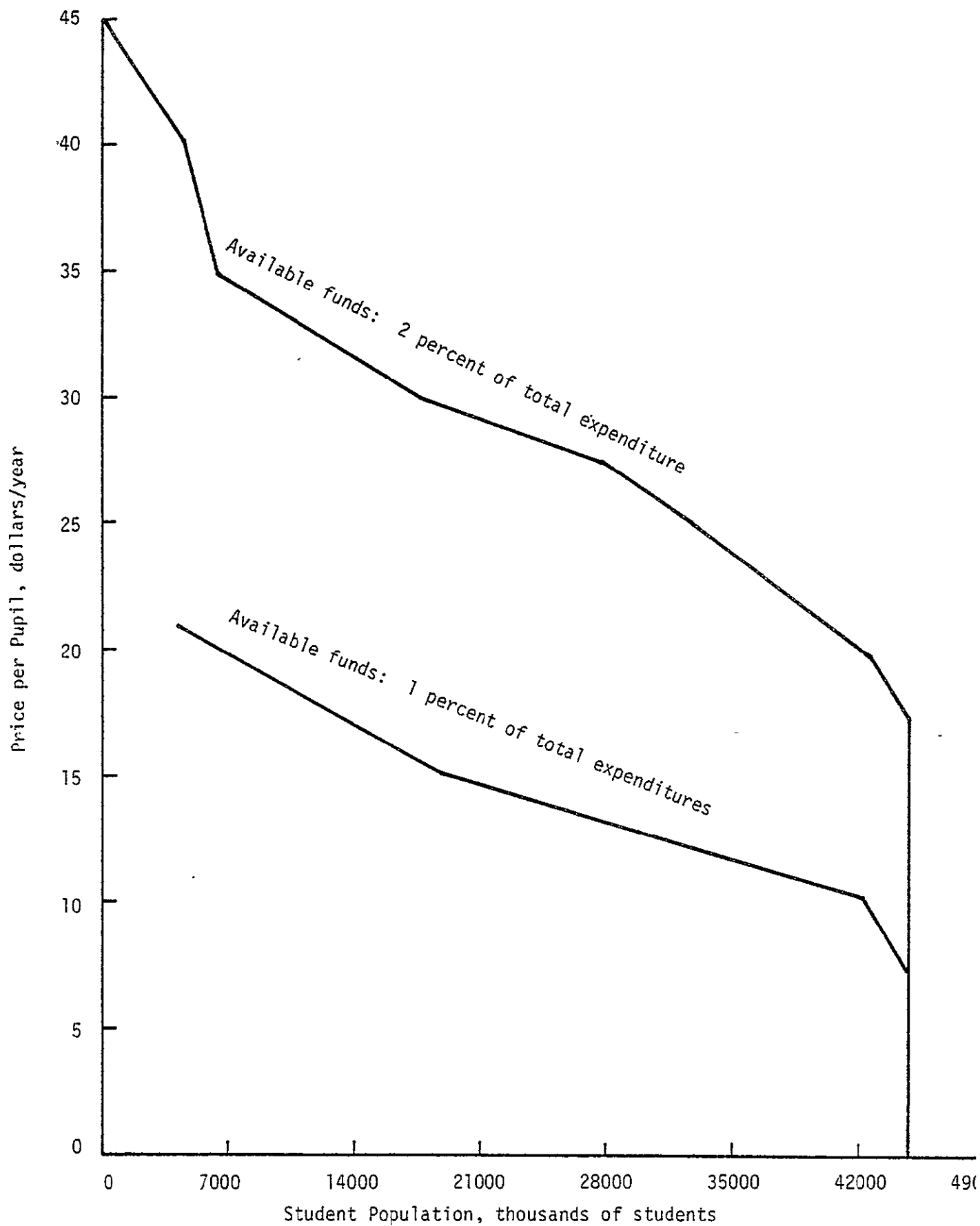
Availability of Capital From States (2% of Total Annual Expenditures)



## Aggregated Student Population Costs

The previous pages indicated those states which could afford certain expenditures per pupil per year. The populations of students in each state has been cumulated at the various price levels and is outlined on the opposite page.

Assuming 1 percent of expenditures per pupil, approximately all enrolled students could participate in an ETV system if the cost was between \$10 to \$15 per year per student. Assuming 2 percent of the total expenditures, most students could participate if the costs were less than approximately \$22 per year per student.



Student Population Which Can Afford ETV in Terms of Price

## Total Available Capital for Various Student Populations

The total available capital for 1 percent and 2 percent allocations of budgets to ETV are outlined in the facing tables. The student population is that population which could, at 1 or 2 percent of the annual expenditure per pupil, afford the indicated price.

It is assumed that the initial cost for the minimum program library is amortized over a five-year period. The program library costs approximately \$72 million to produce and is amortized at the rate of \$14 million per year. This cost is subtracted from the figures in the third column to arrive at the annual capital available, indicated in the fourth column.

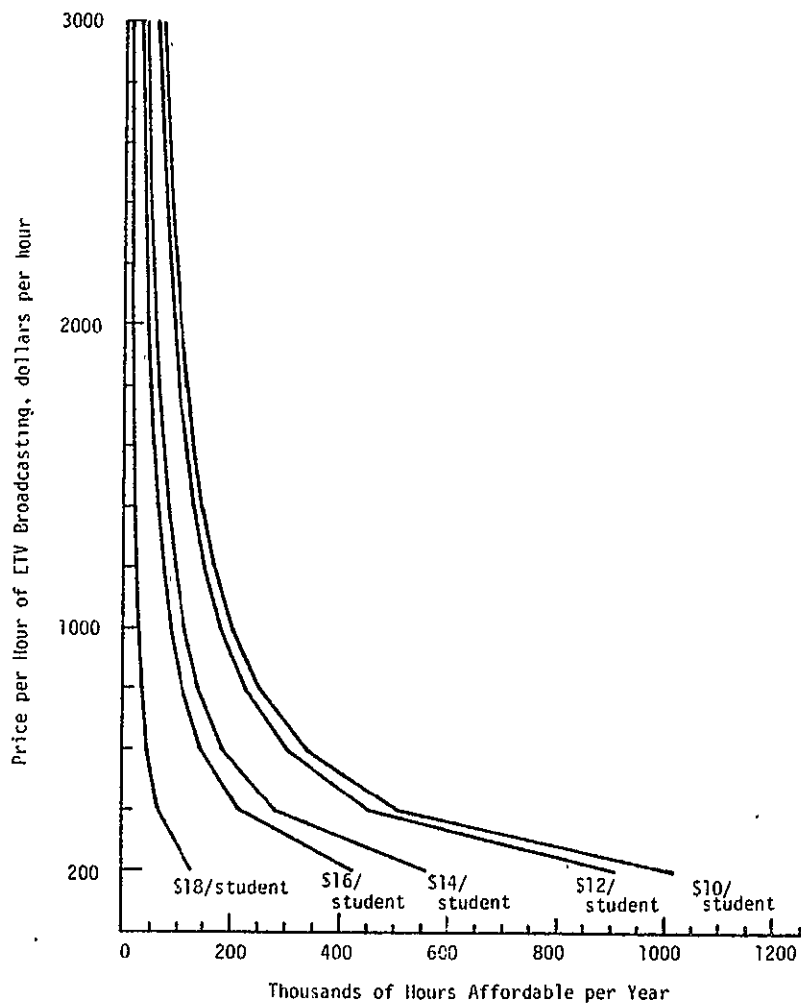
Total Available Capital for Various Student Populations (Funds available are 1% of expenditures)			
Price \$/pupil/yr.	Thousands of Students Served	Total Available Capital for ETV, \$1000/yr.	Total Available Capital ETV Less Programming Costs \$1000/yr.
10	42,076	420,760	406,760
12	31,498	377,976	363,976
14	16,994	237,916	223,916
16	11,501	184,016	170,016
18	3,581	64,458	50,458

Total Available Capital for Various Student Populations (Funds available are 2% of expenditures)			
Price \$/pupil/yr.	Thousands of Students Served	Total Available Capital for ETV, \$1000/yr.	Total Available Capital ETV Less Programming Costs \$1000/yr.
20	42,767	855,340	841,340
25	33,030	825,750	811,750
30	18,068	542,040	528,040
35	11,556	404,460	390,460
40	5,218	208,720	194,720

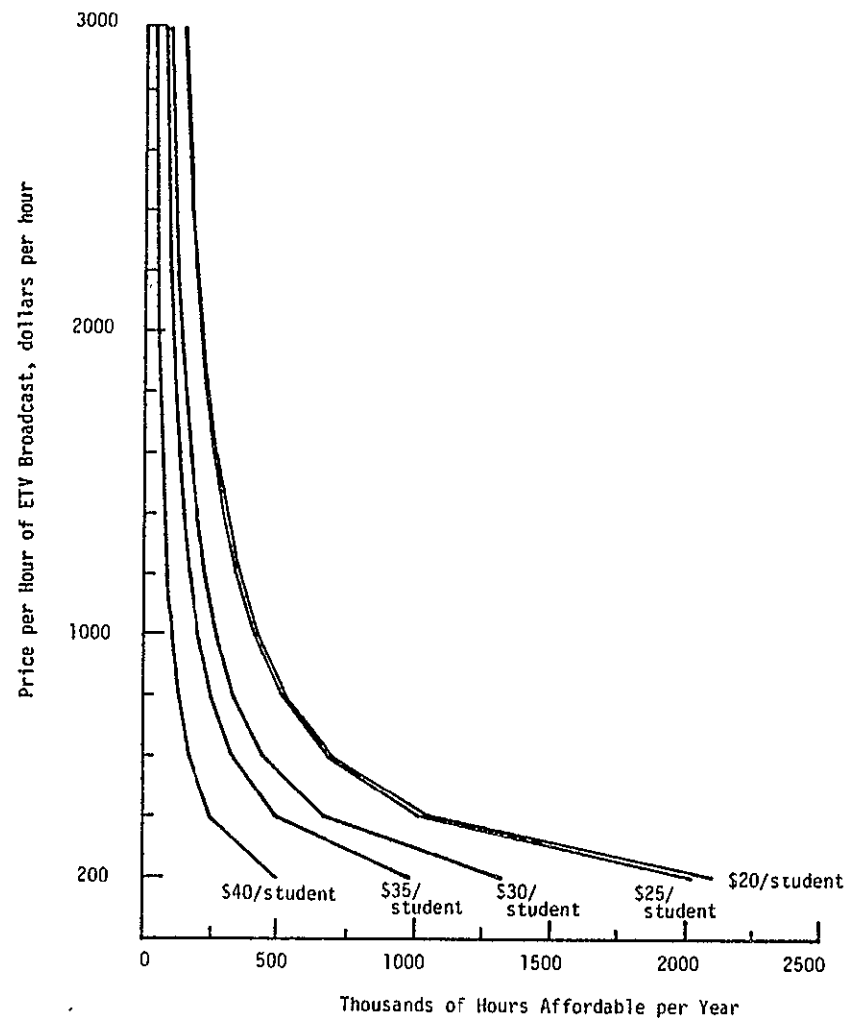
## Total Broadcasting Hours Affordable

The total available funds for ETV broadcasting (from the previous tables) can be related to various costs per broadcasting hour (see facing page). At costs ranging from \$200 to \$3,000 per hour various quantities of ETV broadcasting time could be afforded. Consideration must be given to the management and administration costs which would be incurred in an ETV service. To make a conservative estimate of the percentages of the capital resources allocated to management and administration expenses and actual transmitting and receiving expenses, 50 percent of the available capital has been assumed for management and administration. The remaining 50 percent is used here as the available capital resources for transmission and reception. It is important to also note that the cost of producing the program library has already been separated out from the available capital.

The following graphs indicate the number of hours which could be afforded per year at various expenditures per student per year at prices ranging from \$200 to \$3,000 per broadcasting hour.



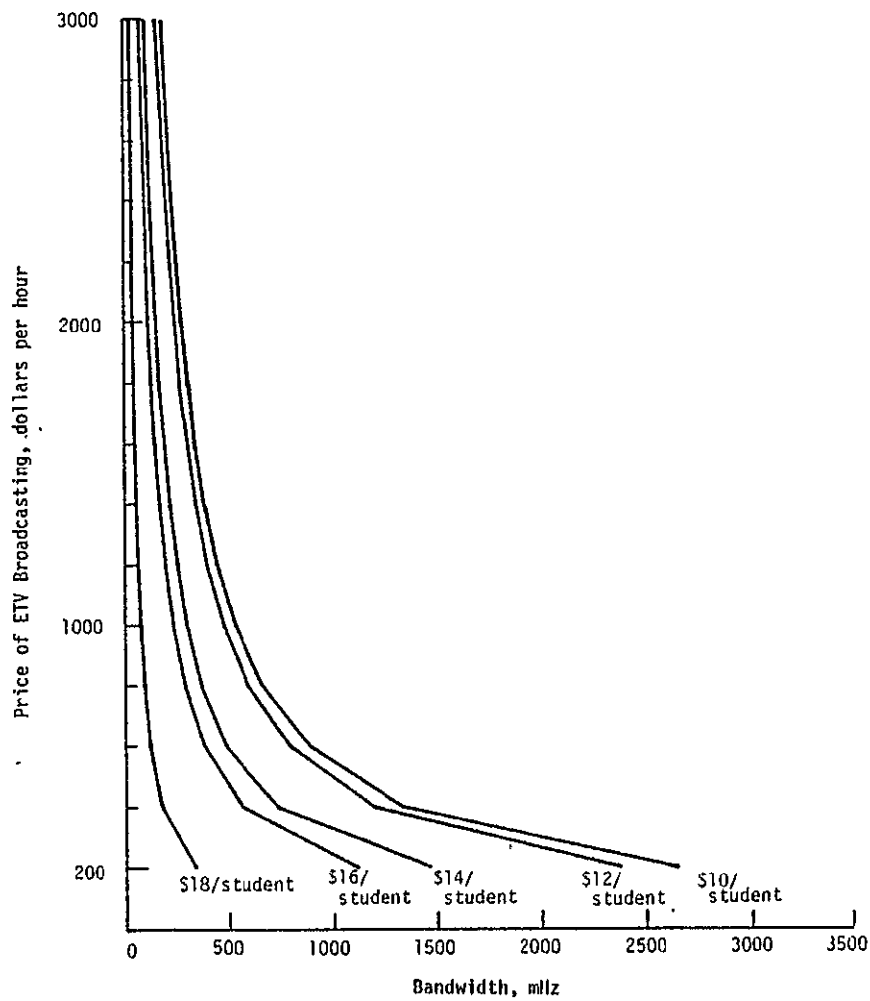
Total Annual Broadcast Hours Affordable in Terms of Price of Service and Funds Available (1% of annual expenditures)



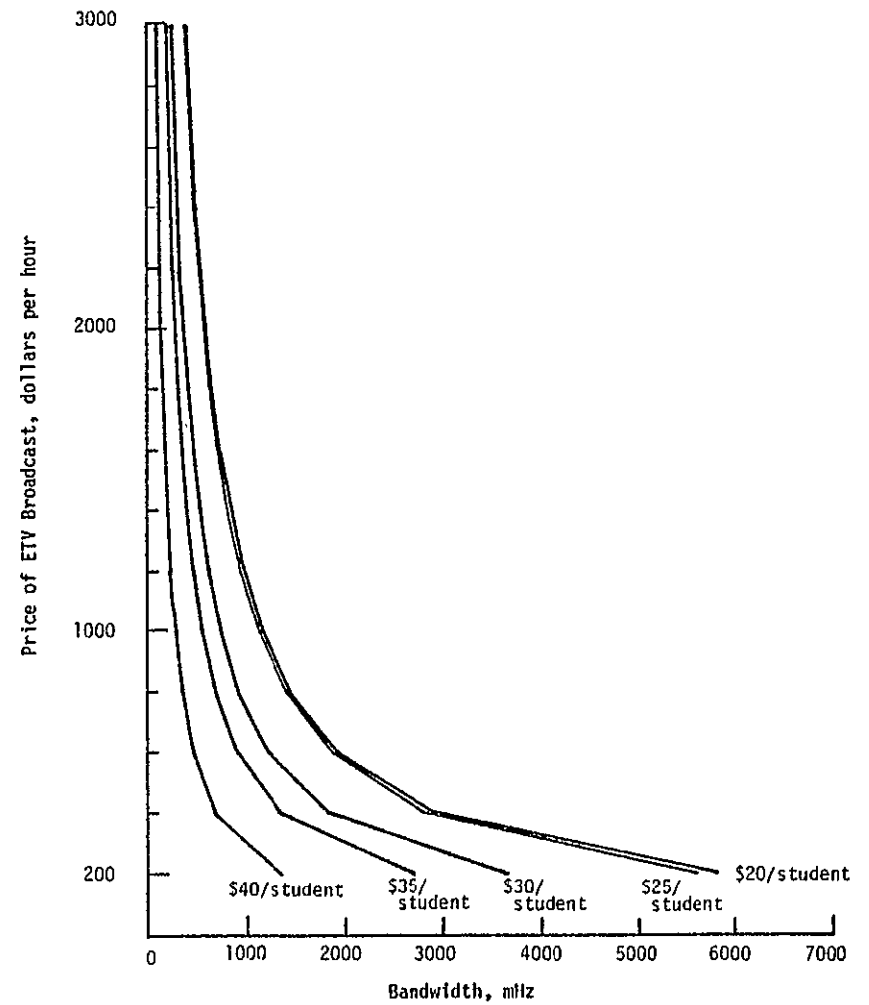
Total Annual Broadcast Hours Affordable in Terms of Price of Service and Funds Available (2% of annual expenditures)

## Demand For Educational Communication Services

In order to be conservative only the data from the previous figure, Total Annual Broadcasting Hours Affordable in Terms of Price of Service and Funds Available (one percent of annual expenditures), has been converted to total required bandwidth. This is accomplished by dividing the total available capital by an average cost of \$1,000 per hour. The result is then divided by 30 school weeks, 5 school days, and 12 hours per day to give the number of channels needed simultaneously each day. The number of channels is then multiplied by a conversion factor of 5 MHz/channel to produce the bandwidth required at various levels of available capital.



Demand for Educational Communication Services  
(Funds available are 1 percent of annual expenditures)



Demand for Educational Communication Services  
(Funds available are 2 percent of annual expenditures)



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## Summary

1. A minimum programming library selection for primary and secondary schools would be 1200 hours.
2. At an expenditure level of less than \$10 per pupil (this being 1 percent of annual expenditure per pupil), 93 percent of the states including the District of Columbia could be expected to afford an ETV satellite service.
3. At an annual expense of \$10 per pupil the total available for an ETV service would be \$420,760,000. Eliminating costs for programming (about \$14 million per year) and administration and management expenses, approximately \$200 million would be available for actual transmitting and receiving expenses.

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ESTIMATION OF  
THE DEMAND FOR  
MOBILE COMMUNICATIONS  
SERVICES

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## Mobile Communications

Because of the type of service to be provided, estimation of the demand curve has been accomplished by making certain assumptions about the new service and making comparisons with other currently existing markets. The use of these other markets for reference does not require substitution of the new service for the old types. Rather, in the case of the standard phone service, the new service is visualized as a service that would be added on to the existing system. In the case of the existing mobile phone service, substitution of the new service is expected if the price for the same quality service is lower or if a better quality service at comparable prices is installed.

Note: The "price" referred to throughout is the price to the user or user charge.

## Mobile Communications

### Service Description

- Car Phone Service
- Immediate Access To Direct Dialing System
- Available Throughout U.S.
- Ring With Home Phone If Desired

## Current Market

Mobile: Monthly rental fees vary with the location and the type of service from \$63 per month to \$94 per month. An average of \$80 per month has been assumed. In addition, there is a radio air charge of \$0.25 per minute for all calls in addition to long distance rates. Since it is assumed that if a mobile phone is not used, it will be removed, it seems reasonable to assume an average of 120 calls per month at 4 minutes per call. According to the FCC, there are 25,000 mobile phones which currently operate under blanket licenses and 20,000 which operate under individual licenses. It is also assumed that those mobile phones which currently operate under blanket licenses are for business use, while those with individual licenses are for private use.

Standard: The numbers of telephones in the standard system as published in Statistics of Communication Common Carriers are presented here. The average monthly price of \$8 represents the average monthly charge for equipment rental and local service for a single main phone. This is not to be confused with the average operating revenues to telephone companies. This figure is \$24.50 which includes local and rental charges plus toll charges, special service charges and other miscellaneous fees.

# Current Market

Mobile	Number	Price
Individual	20,000	Monthly rental
Business	<u>25,000</u>	120 calls at
Total	45,000	4 min. each
		\$ 80.00
		<u>120.00</u>
		\$200/mo.
Standard		
Main	78,744,000	Monthly rental
Resident ext.	45,199,100	and local
Business ext. & PBX	<u>20,028,900</u>	Service
Total	143,972,000	
		\$ 8/mo.



## Household Use Of Car Telephones: Potential Market

The potential market for mobile phones is expected to be an average of one car phone per each household that owns one or more cars. It is also assumed that the average household would be able to spend a maximum of 5 percent of their income on telephone services. This maximum of 5 percent would cover both home and mobile services, therefore, in order to demand a mobile phone, if the price were \$8 per month, a household must make at least \$4,000 per year.

$$\begin{array}{rcl} \$ & 8/\text{mo. home charge} & \$4000 \text{ yearly income} \\ + & 8/\text{mo. mobile charge} & \underline{\times .05} \text{ maximum fraction payable to} \\ \$ & 16/\text{mo.} & \text{telephone} \\ \hline & \times 12/\text{mo./yr.} & \\ \$192 \text{ yearly telephone charge} & \approx & \$200 \text{ maximum payable for telephone} \\ & & \text{service} \end{array}$$

A similar rationale follows at each income level.

The range in potential market shown here results from two different sources of income distribution data. The lower bound is obtained by using the distribution of individual Income Tax Returns (1972), adjusted gross income to estimate the potential market. The upper bound applies the same method to the income distribution for 1973 (the distribution changes very slowly over time) as published in Historical Statistics of the United States.

### Household Use of Car Telephones

Required Income Level	
Price of Service	Required Income
\$200/mo.	≥ \$50,000
\$100/mo.	≥ \$25,000
\$ 50/mo.	≥ \$14,000
\$ 25/mo.	≥ \$ 8,000
\$ 8/mo.	≥ \$ 4,000

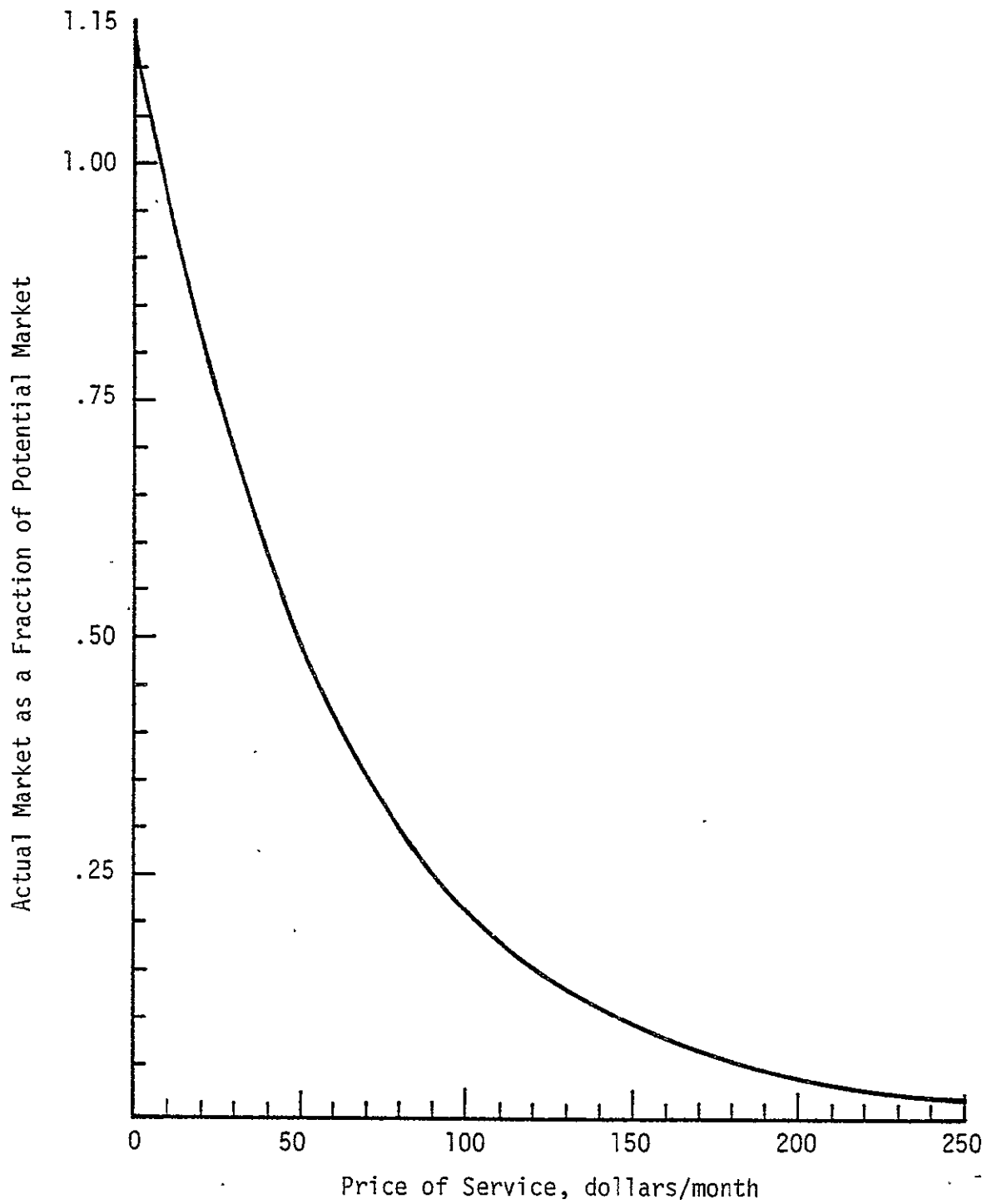
Households Owning Cars*	
Annual Income	Percent of Households With One or More Cars
Under \$3,000	40.6
\$ 3,000- 4,999	68.0
5,000- 7,499	84.2
7,500- 9,999	91.3
10,000-14,999	94.9
15,000-24,999	96.5
25,000 and over	93.0
*Source: Statistical Abstracts, 1974, U.S. Department of Commerce	

Potential Market	
Price of Service	Number of Households, millions
\$200/mo.	.5- .5
\$100/mo.	2.6- 5.0
\$ 50/mo.	14.1-23.2
\$ 25/mo.	31.7-41.1
\$ 8/mo.	42.3-50.1

### Expected Potential Market - Actual Market Conversion Curve for Households

The potential-actual market conversion is necessary because at different price levels for the new service, the percent of those households which are capable of purchasing the service that actually do buy the service will vary. This is true largely because increasing numbers of car phones will make the service increasingly valuable in that these would increase opportunity to use the service because of the increased number of phones to call and the increased likelihood of connecting with the desired party.

The following curve presents the anticipated percentage of the potential market which is likely to actually purchase the service as a function of price (\$ per month). At \$200/per month (current market price), only 4 percent of those who can afford the service have a car phone. However, at \$8 per month, essentially everyone who can purchase telephone service has it. The exponential curve applied between these two end points describes the likely conversion from potential market to actual market.

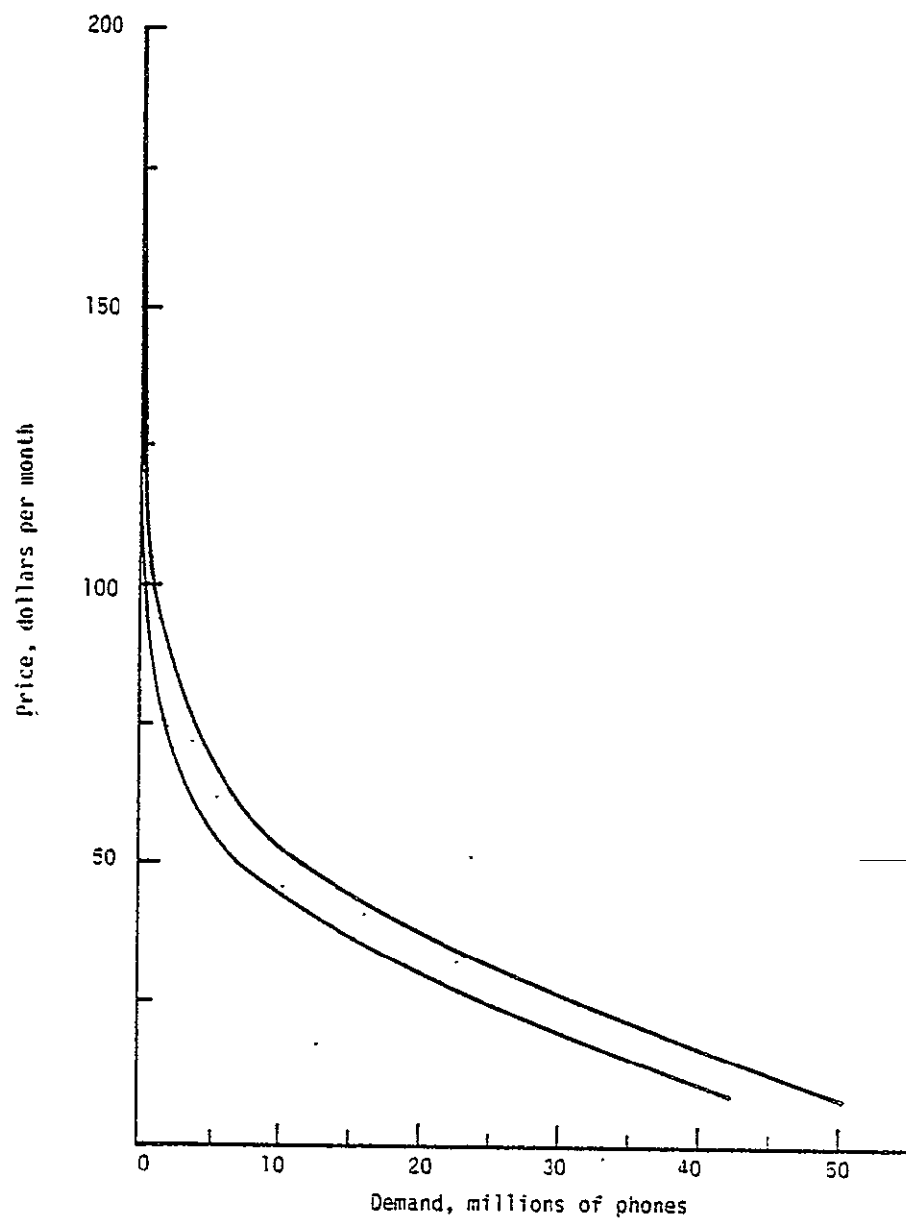


Expected Potential Market-Actual Market Conversion Curve for Households

## Household Demand for Car Phones

The demand curve is the product of the potential market and the fraction of that market which is expected to actually purchase the service at given price levels.

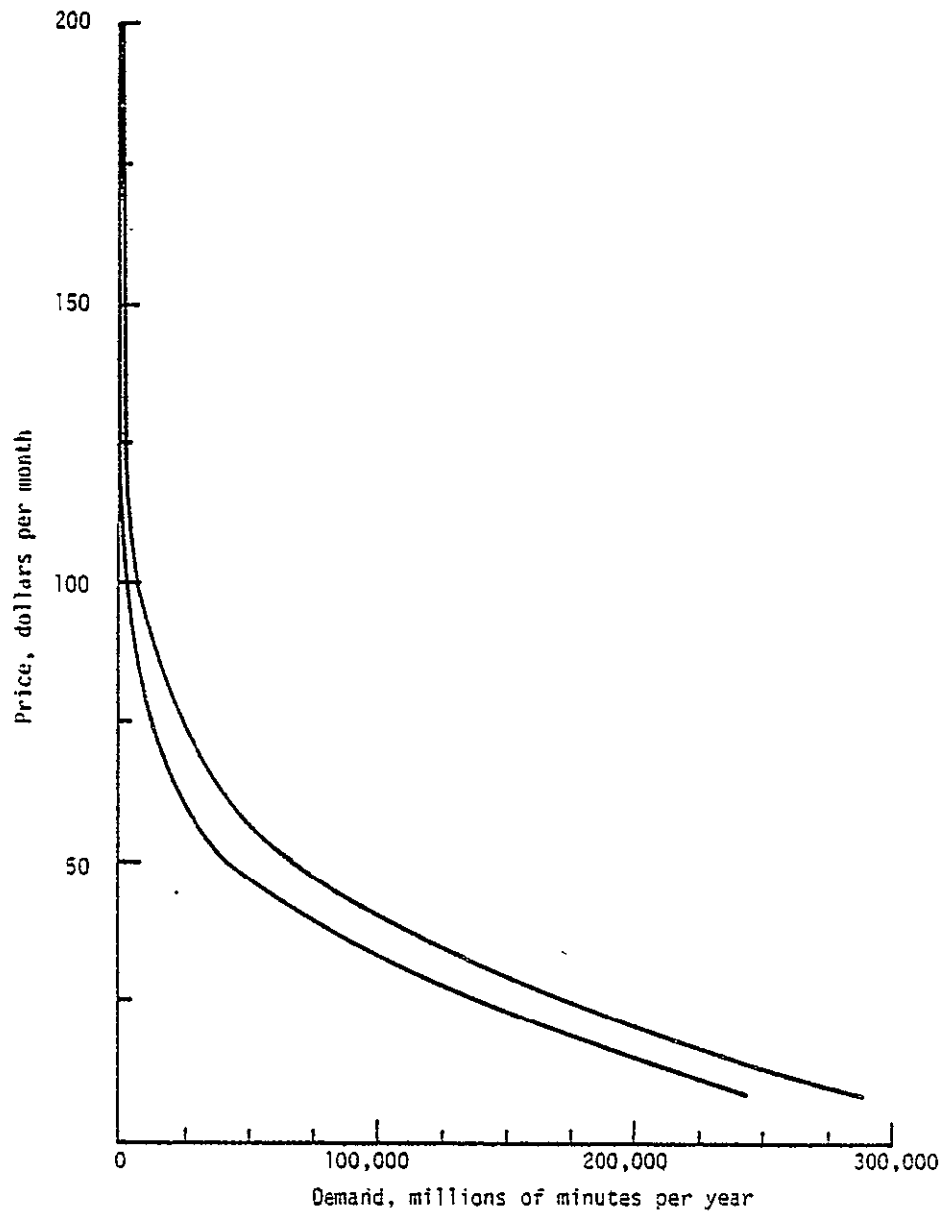
Household Demand for Car Phones					
Price, dollars per month	Potential Market, millions of households	Potential Market- Actual Market Conversion factor	Demand, millions of car phones	Demand, millions of minutes per year	Demand, average bandwidth required (mHz)
200	.5 - .8	.04	.02- .02	115- 115	.8 - .8
100	2.6 - 5.0	.21	.5 - 1.1	2880- 6336	21.9 - 48.2
50	14.1 - 23.2	.49	6.9 - 11.4	39744- 65664	302.5 - 499.7
25	31.7 - 41.1	.76	24.1 - 31.2	138816-179712	1056.4 - 1367.7
8	42.3 - 50.1	1.00	42.3 - 50.1	243648-288576	1854.2 - 2196.2



Household Demand for Car Phones

#### Household Demand for Car Phones: Minutes Per Year

- The number of minutes demanded per month is derived by using the assumption that an average of 120 calls per month at 4 minutes per call will be demanded per car phone.

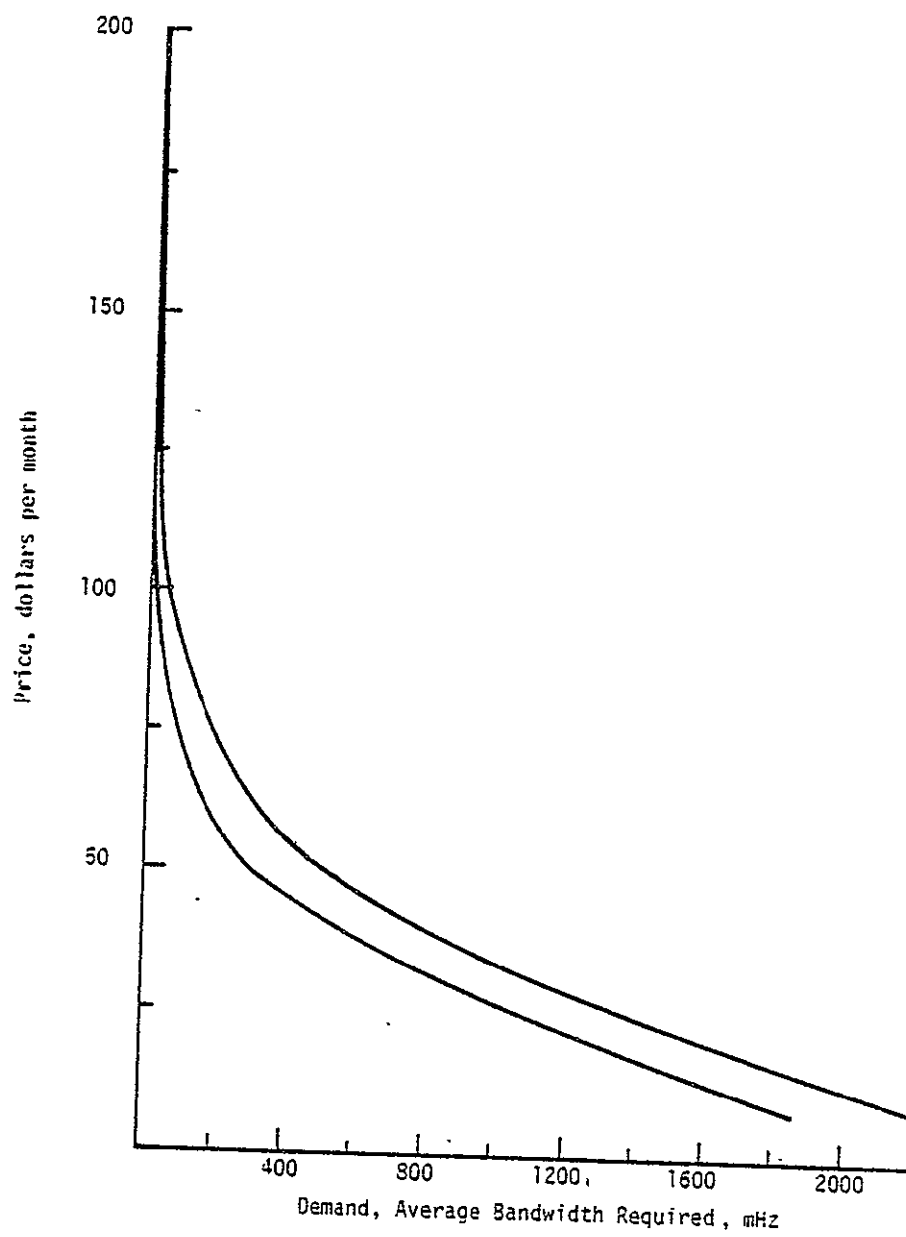


Household Demand for Car Phones



### Household Demand For Car Phones: Average Bandwidth Required

The average bandwidth required is obtained by multiplying the required minutes by 4 kHz required for two-way voice transmission. The quantity indicated in the facing figure is the average bandwidth required. Note that all estimates are based on average figures. Additional bandwidth may be required to handle peak loading situations but this area is not addressed here. Also not addressed is the possible reduction in bandwidth which might result from efficient coding or speech compression techniques.



Household Demand for Car Phones

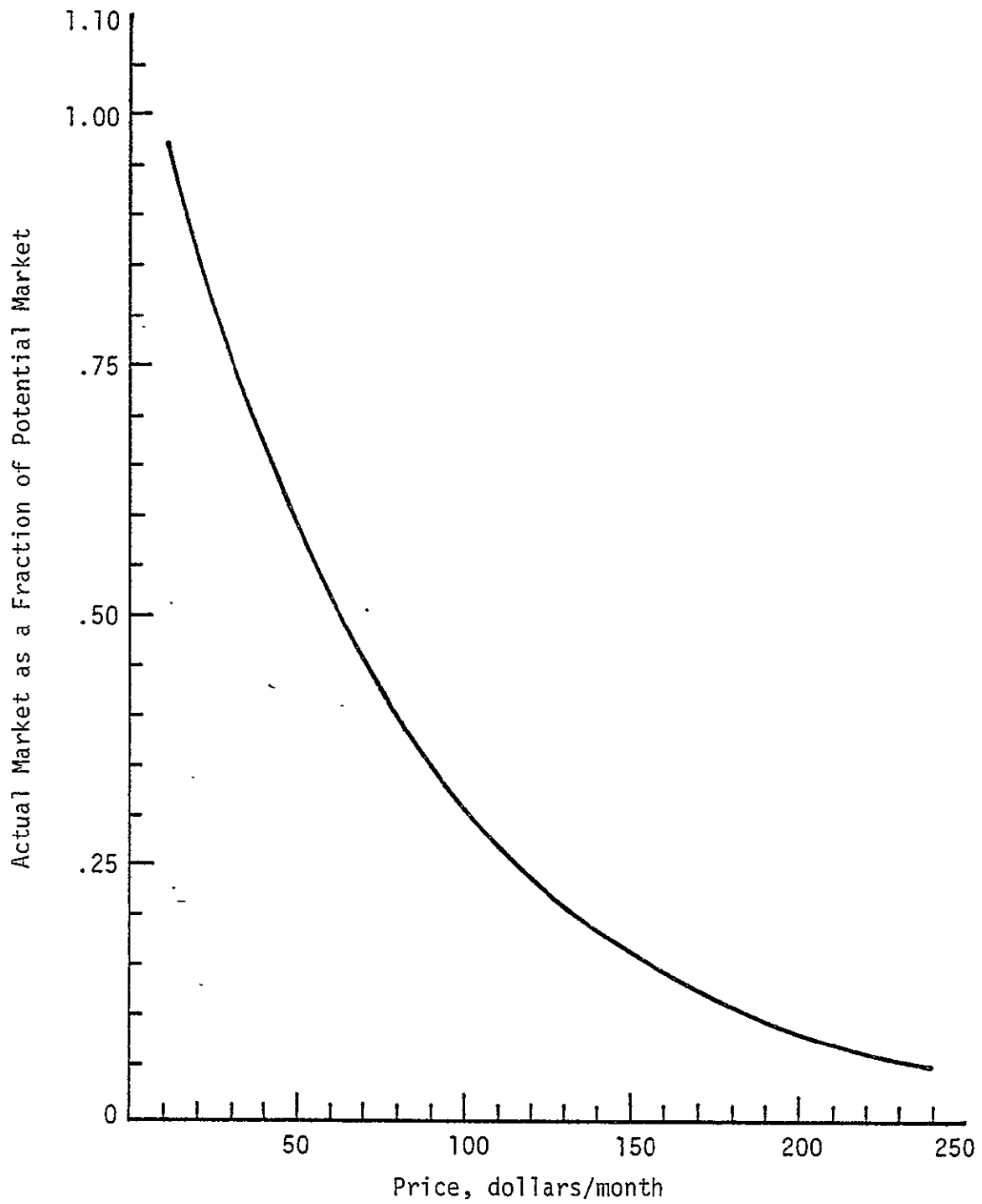
### Business Demand - Potential Market

The potential market for car phones in business was obtained by dividing the total business receipts per year by the number of business phones. It was determined that an average of \$65,000 receipts per year are required, to support a business telephone. This is assumed to be the minimum amount of receipts necessary to be in the market for a car phone. This number corresponds to the \$4,000 individual income required to be the market for car phones for the household. Since the minimum required business receipts is 16.3 times greater than the minimum required income for households, this factor is applied throughout the distribution.

Business Demand - Potential Market			
Potential Market			
Price, dollars/month	Required Receipts, dollars/year	Number of Businesses (1000)	% of All Businesses
200	≥ \$850,000	284	2.2
100	≥ \$400,000	745	5.7
50	≥ \$250,000	1222	9.4
25	≥ \$150,000	1540	11.9
8	≥ \$ 65,000	2456	18.9

Expected Potential Market - Actual Market Conversion  
Curve For Business

The conversion curve from potential market to actual market for business is obtained in the same manner as that for households. At \$200/month, 9 percent of the potential market is presently purchasing the service. At \$8/month, essentially the entire potential market enjoys telephone service.

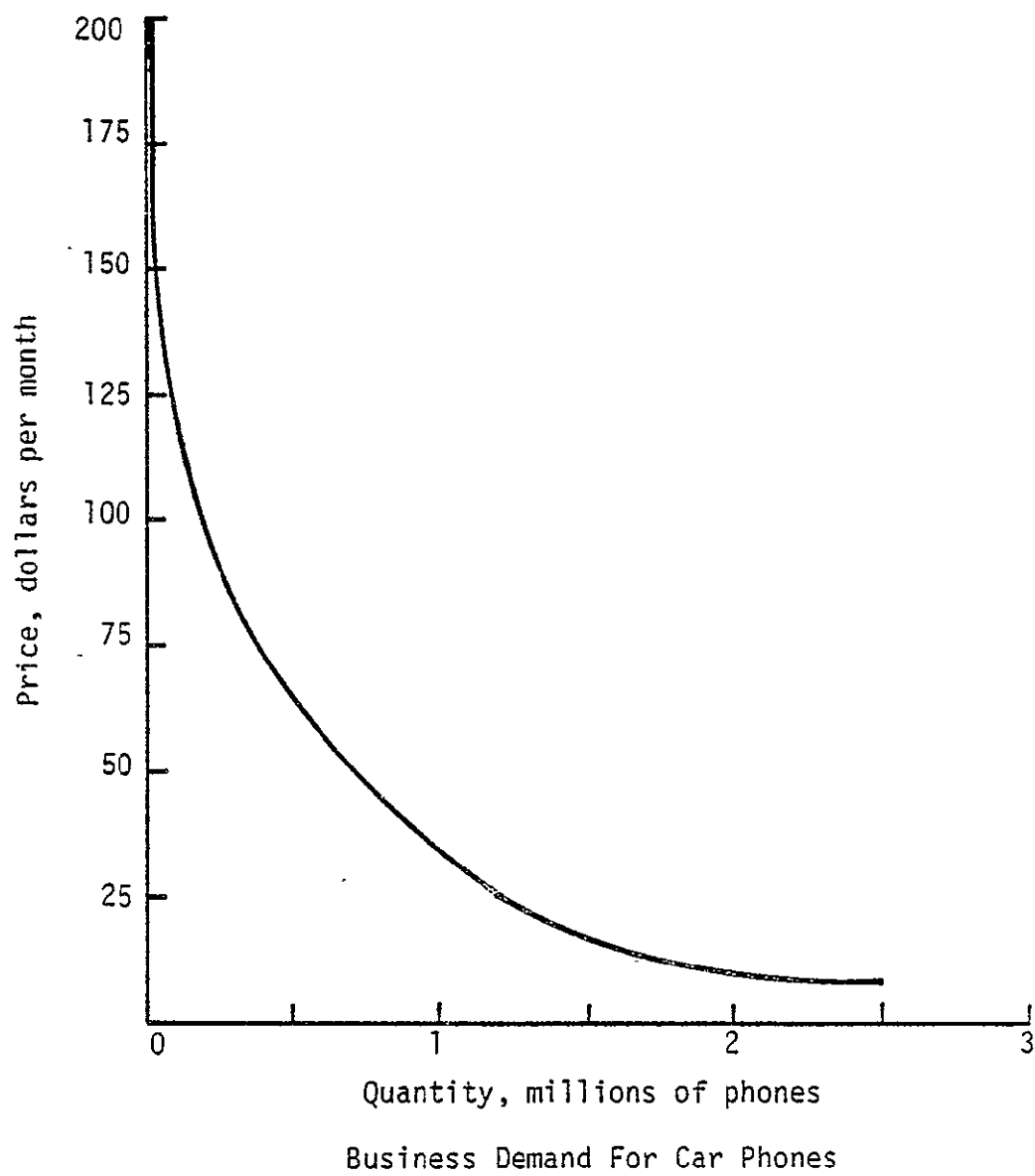


Expected Potential Market--Actual Market Conversion Curve for Business

### Business Demand For Car Phones

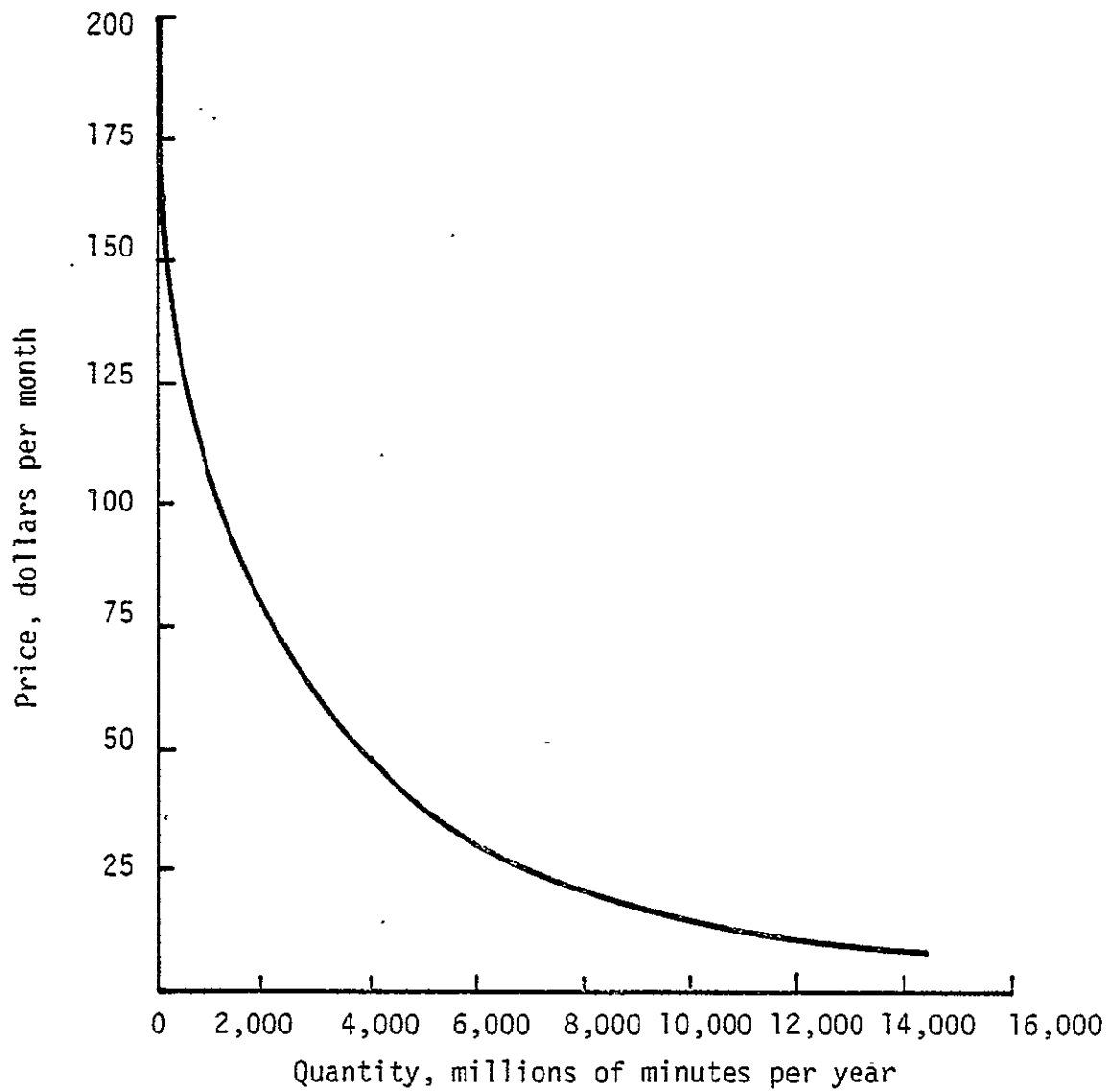
The demand for car phones by business is obtained using the methodology presented for household demand. The assumptions with respect to the number of calls per month and the duration of the calls do not change. The three figures on the following pages present this demand in terms of number of phones, minutes per year and average bandwidth required.

Business Demand For Car Phones			
Price, dollars per month	Demand, millions of car phones	Demand, millions of minutes per year	Demand, average bandwidth required (mHz)
200	.02	115	.8
100	.2	1152	8.0
50	.7	4032	28.0
25	1.2	6912	68.0
8	2.5	14400	100.0





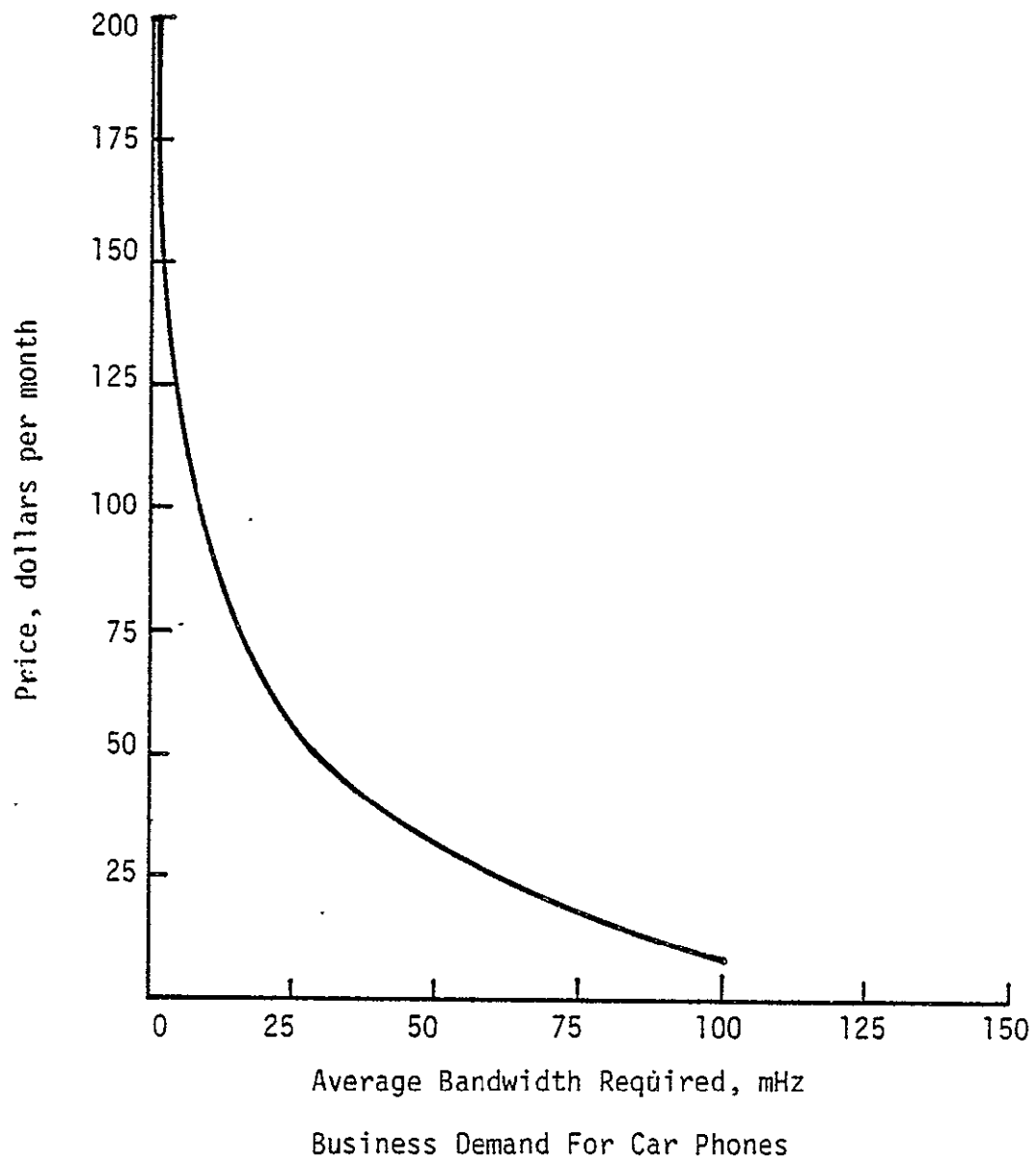
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Business Demand For Car Phones

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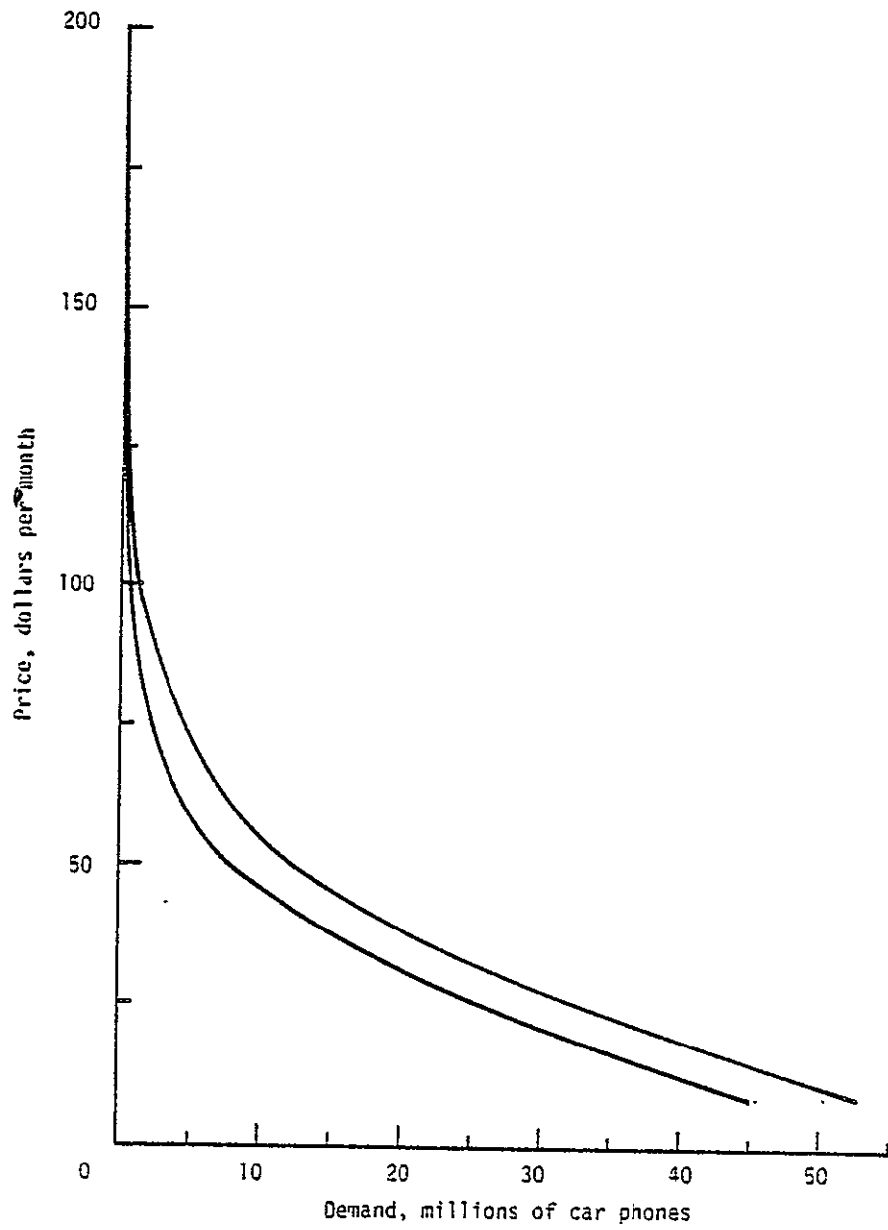


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### Total Demand for Car Phones

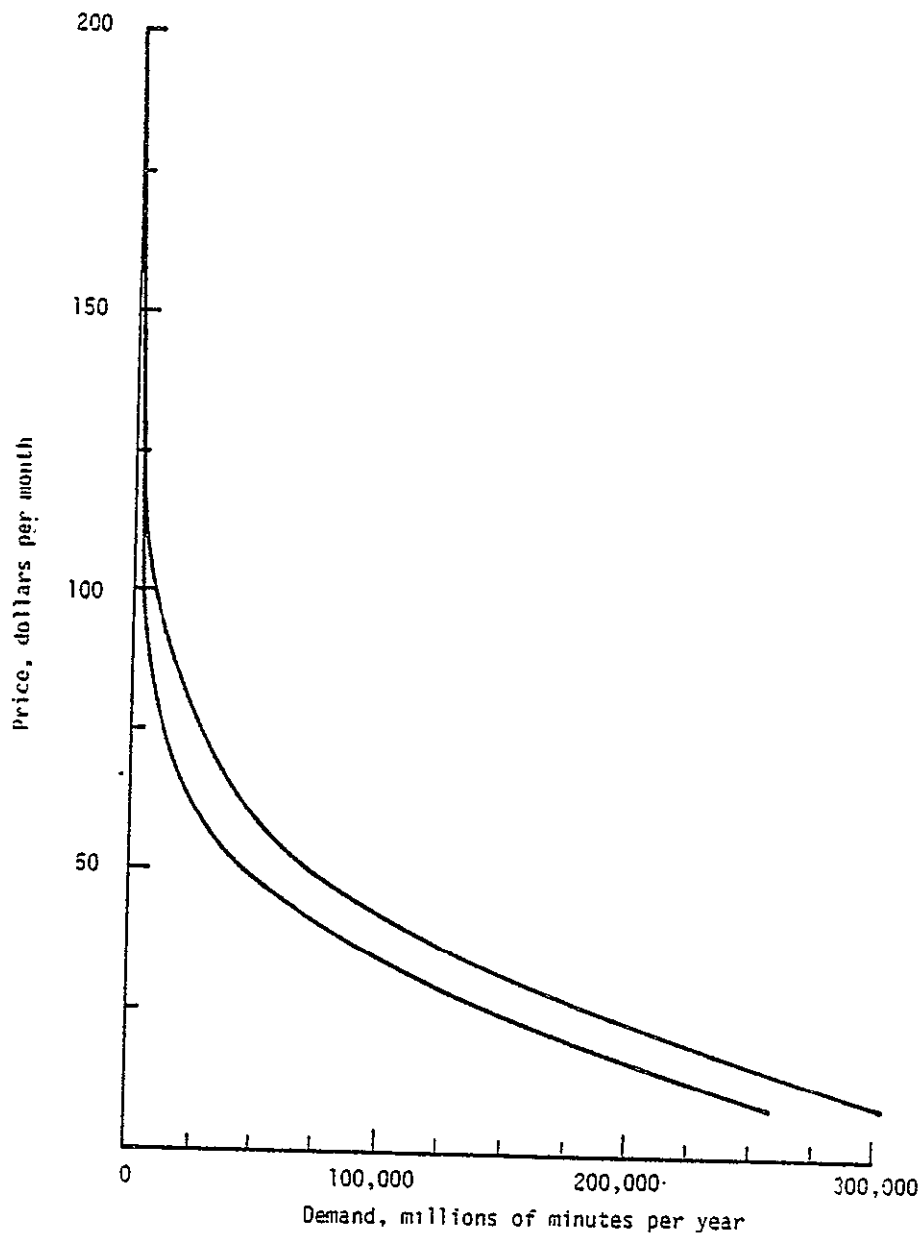
The total demand (business plus household) is presented in the following three figures in terms of numbers of phones, minutes per year and average bandwidth required. The total demand for car phones is strongly dependent on the price and potentially quite large. The service will be used by business and households with the majority of the demand from the household sector. If the average price was in the range of \$200 per month to \$8 per month, the number of phones demanded would vary from 40,000 to 52.6 million and the average bandwidth required from 1.6 mHz to 2296.2 mHz.

Total Demand for Car Phones			
Price, dollars per month	Demand, millions of car phones	Demand, millions of minutes per year	Demand, average bandwidth required (mHz)
200	.04- .04	.230- 230	1.6- 1.6
100	.7- 1.3	4,032- 7,488	29.9- 56.2
50	7.6-12.1	43,776- 69,696	330.5- 527.7
25	25.3-32.4	145,728-186,624	1124.4-1435.7
8	44.8-52.6	258,048-302,976	1954.2-2296.2



Total Demand for Car Phones  
(business plus households)

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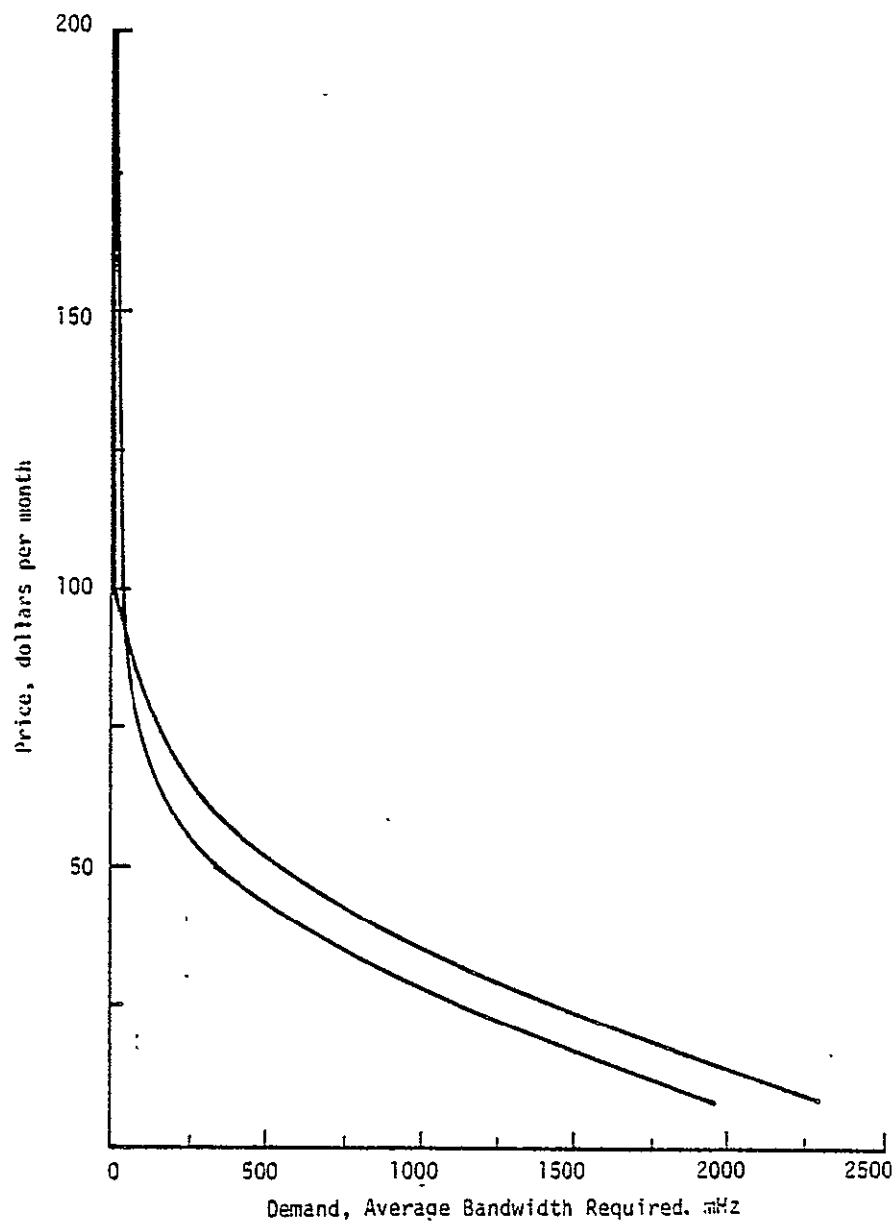
Total Demand for Car Phones  
(business plus households)

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1961-1962 CAR PHONE PLANS FOR NEW



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Total Demand for Car Phones  
(business plus households)

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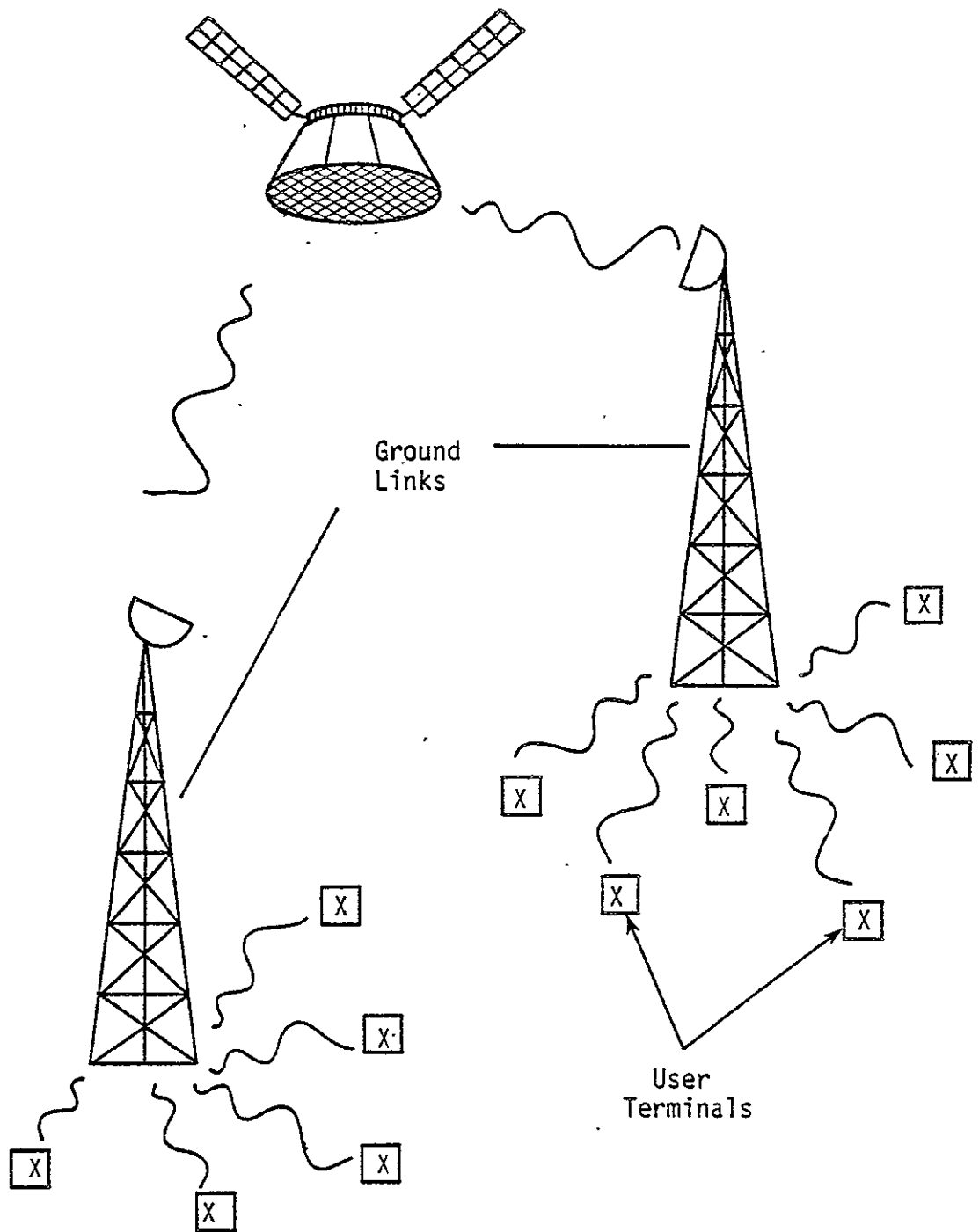
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ESTIMATION OF  
THE DEMAND FOR  
ELECTRONIC MESSAGE TRANSFER  
SERVICES

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## Electronic Message Service - System Description

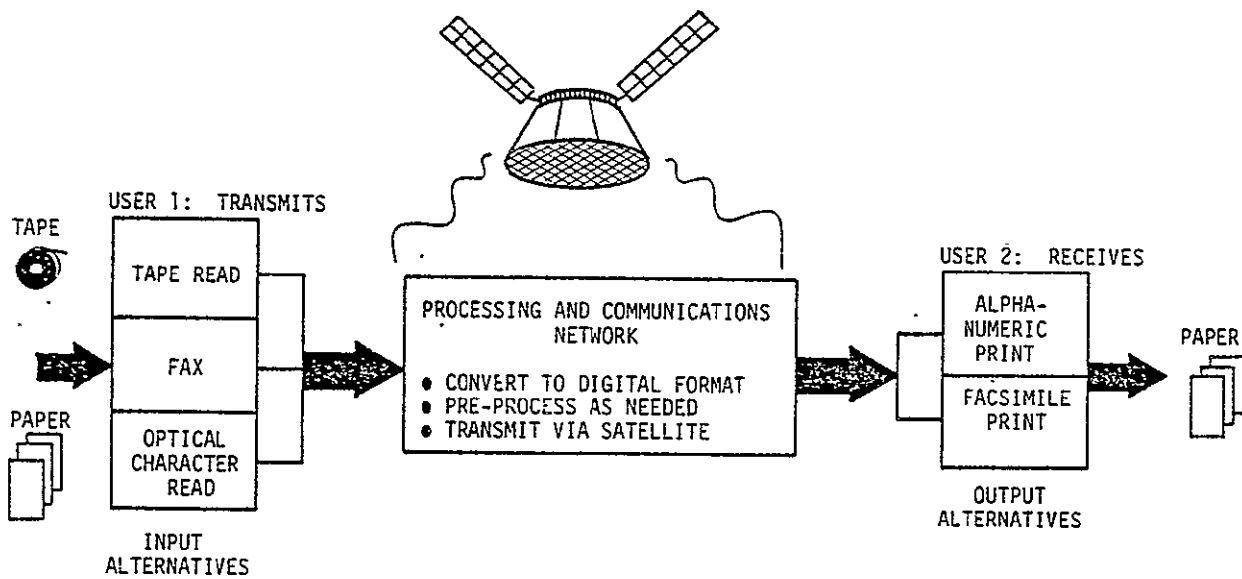
The following demand model for an Electronic Message Service (EMS) is based on a loosely-defined set of system characteristics. It is assumed that a likely system would consist of a network of message handling facilities that would accept messages in many forms and convert them for transmission via satellite. While each participant in the system would purchase or lease his own transmit-receive capability, it is expected that terrestrial links would join each earth facility to a larger, more central satellite earth terminal, which would carry out the long-distance transmission and reception of messages. Alternatively, the individual terminals could be connected directly through the satellite. The satellite or satellites would operate at frequencies above 10 GHz, accepting digitally modulated signals. Forward acting error encoding would be used to achieve suitable low bit error rates, and time division multiple access (TDMA) or similar methods would be employed to fulfill the need for switching. It is further envisioned that the satellite earth terminals would be equipped with store-and-forward message switches, which would be used to distribute messages to the individual users.



Electronic Message Service - Network

### User View of System

The user terminals are expected to have several input/output options which allow transmission and reception of direct digital, alphanumeric and facsimile-type messages. The fixed cost to the user would be the lease or purchase price of his terminal, while recurring costs would be assessed on a per-unit or time-service basis. The system would be available to users 11 hours each working day, to allow for 8 hours of transmit/receive overlap between most points in the continental United States.



Assumptions:

- Users to purchase or lease a transmit-receive capability, with several possible input/output combinations
- Recurring costs to be assessed on per-unit or service-time basis

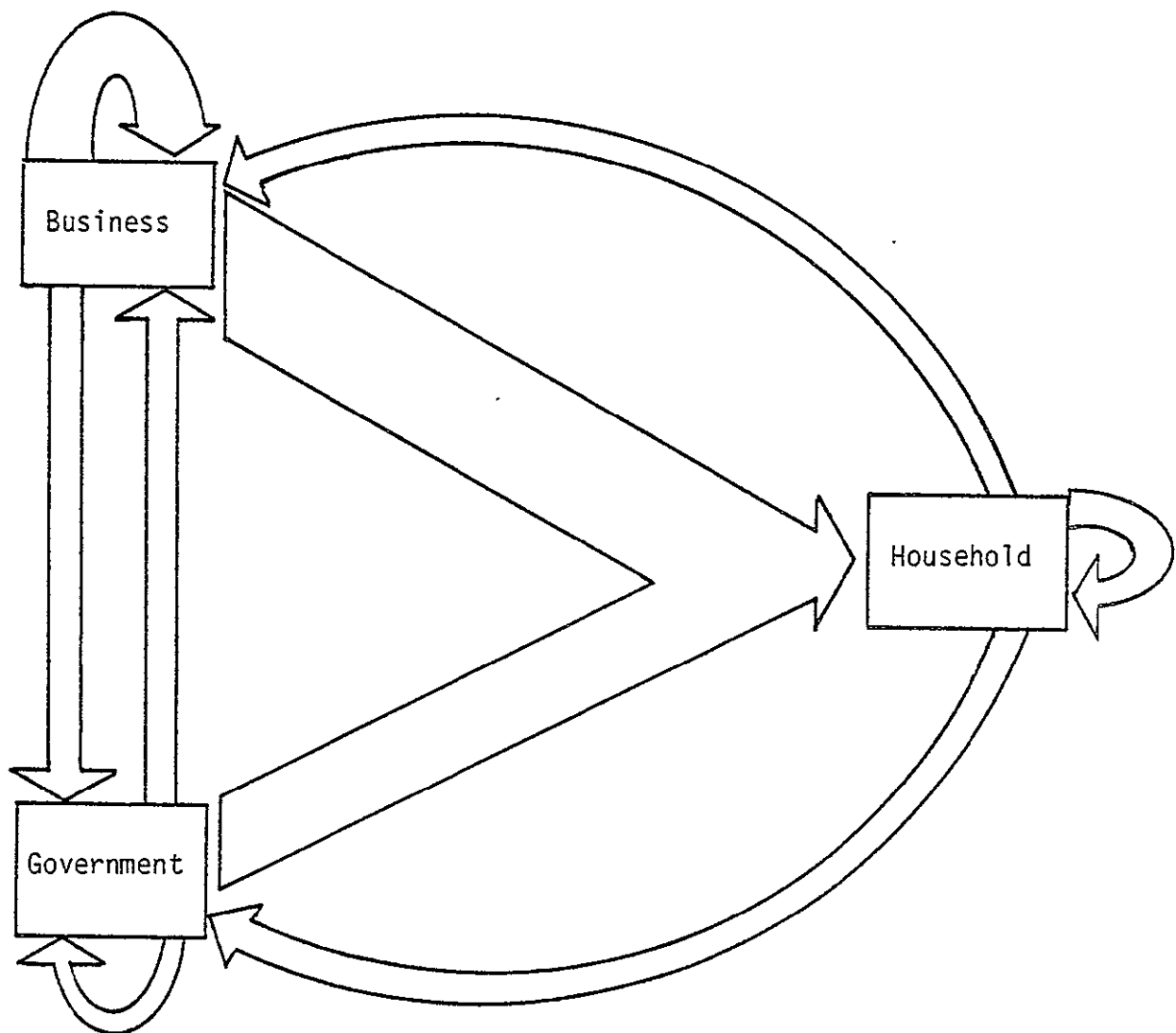
User View of System



## Household Demand for EMS

Overall, when all message services are considered, the most heavy flow occurs between business and individual households. Although there are almost 70 million households nationwide, it is difficult to justify economically the participation of the household sector (in part or in full) in an EMS system. This is true for several reasons:

- Households receive many more messages than they send,
- Message-service expenditures by households are very small,
- Participation would require a large fixed cost and it is questionable whether this would be equated with many small recurring costs in the household decision process,
- The system's improved quality (speed and reliability) are not likely to be important to the household in dollar terms,
- Households would, in effect, be paying to receive messages if they did participate in the system,
- Today there is no cost to receive messages, and
- Noneconomic factors such as resistance to innovation play a relatively large role in household decision-making, and are likely to impede household participation.



Sectoral Message Flows

## Business Demand for EMS

Potential demand for an EMS by business is less ambiguous. The following are contributing factors:

- Firm decision-making is based almost entirely on cost minimization and is thus very predictable,
- Expenditures on message services by the business sector today are large, and the expected savings potential of an EMS system is high,
- Demand for message services today is fairly inelastic: The profit-making activities of most firms are dependent on their ability to send (and receive) messages,
- Businesses would benefit from improved quality in dollar terms; in particular, speed, reliability and convenience are likely to be important considerations, and
- Barriers to innovation are low when a clear-cut economic benefit is seen.

Average Proportion of Mail Directly Related to Profit-Making Activities

Industry	All Mail, %	1st Class, %
Utilities	78	91
Financial Institutions	71	98
Securities	80	98
Insurance	79	94
Credit Cards	56	88
Department Stores	78	85
Retail Trade	69	80
Wholesale Trade	76	97
Consumer Goods Mfg.	76	95
Textiles, Clothing, Paper/Wood	79	98
Chemicals and Allied Products	73	98
Manufacturers - Heavy Industrials	74	99
All Other Manufacturers	77	96
Specialty Mailers	65	100
Books and Records	93	93
Publications	73	93
Other Printing Services	75	98
Transportation	75	94
Other Service Industries	51	92
Government	--	75
Non-Profit	21	60
Miscellaneous	55	86
	—	—
Total weighted average	71%	94%

Source: U.S. Postal Service Business Mailers Study, Market Research Division, August 1975.

## Substitution of EMS for Existing Services: Overview

A General Dynamics study completed in 1970\* indicates that the following business message categories are generally electronically transmittable: general correspondence; data; sales letters and brochures; annual reports; purchase orders; acknowledgements of orders; invoices; statements of account; reminders and duns; general legal and financial correspondence; contracts; bids; plans. Excluded are payments for goods and services and advertising, although alternative EMS plans have been devised which would allow for inclusion of these two categories.

The existing hard-copy message services which might be replaced in whole or in part by an EMS can be grouped under three headings: mail services, which include seven types of service currently provided by the United States Postal Service; telecommunications, which includes Mailgram, Telex and facsimile-type services; and special carrier services such as Air Courier.

---

\*"Study of Electronic Handling of Mail", General Dynamics, Electronics Division, August 1970.

### Existing Hard-Copy Message Services

#### Surface Mail

- First Class Mail
- Airmail
- Special Delivery
- Express Mail
- Air Priority Mail
- Certified Mail
- Registered Mail

#### Telecommunications

- Mailgram
- Dataphone 50
- TWX
- TELEX
- Fax Services

#### Special Carriers

- Messenger Services
- Air Courier

## Substitution of EMS for Existing Services

A straightforward approach to determining which of the existing message services might be replaced by an EMS consists of examining the percentage of each service's message content which falls into the electronically-transmittable categories.

Of the 14 services for which data was available, there are three services for which the top four categories of messages sent corresponded exactly to four specified categories of electronically-transmittable messages. These are:

- Mailgram,
- First Class Mail, and
- Airmail.

At the opposite end, there are four services for which only one of the specified categories was ranked in the top four categories of messages sent. These are:

- Special Delivery,
- Air Courier,
- Registered Mail, and
- Fax Services.

However, in the case of Fax Services and Special Delivery, the percentage of total messages sent which fall into the four specified categories is quite large, indicating that there is likely to be a moderate-to-large substitution effect if an EMS is instituted.

Substitution of EMS for Existing Services						
Service	Message Categories				Percentage of total sent which falls in Categories 1-4	Others of Significance
	1	2	3	4		
Mailgram	X	X	X	X	94	
First Class Mail	X	X	X	X	84	
Airmail	X	X	X	X	92	
Dataphone 50	X		X	X	98	
TWX	X		X	X	94	
TELEX	X			X	80	Shipping papers
Special Delivery	X				72	
Fax Services	X				51	Architectural drawings, shipping papers
Express Mail			X	X	49	
Air-Priority Mail	X		X		45	
Messenger Services	X		X		52	
Certified Mail	X	X	X		41	
Air Courier	X				22	
Registered Mail	X				12	

Key: X = If one of top four categories sent by service corresponds to indicated category:

1 = General correspondence, intrafirm and interfirm.

2 = Bills, quotations, sales letters and brochures.

3 = Policies, statements, contracts, general financial

4 = Orders, bids, general transactional (excluding money exchanges)

Source: USPS Business Mailer Study, 1975.



### Substitution of EMS for Existing Services

In sum, there is likely to be significant substitution in the case of all but two of the services examined. Although there are many services from which an EMS might pull demand, First Class Mail and Airmail (with approximately 55 billion message units sent per year) are overwhelmingly the largest and most widely used. For this reason, these services have been selected as the base for the EMS substitution-demand model.

## Substitution of EMS for Existing Services

### Very high degree of substitution likely:

- 1st Class Mail
- Airmail
- Mailgram
- TWX
- Dataphone 50 (and similar services)

### Large degree of substitution likely:

- TELEX
- Special Delivery

### Moderate-to-Large Substitution:

- Fax Services
- Express Mail
- Air Priority Mail
- Messenger Services
- Certified Mail

### Little substitution:

- Air Courier
- Registered Mail

### Substitution of EMS for First Class Mail

A breakdown of first class mail flows bears out the earlier conclusion regarding the households: 64 percent of the total mail sent flows to the household sector, with household contribution to overall flow only 21 percent. (Portions of this go to business and government, as well as other households.)

Note that business receives 80 percent of its mail from business, and sends 36 percent of its mail to recipients within the business sector. These flows yield a figure of between 13 and 14 billion as the total yearly message flow within the business sector, for first class mail and airmail. This total would, of course, be larger if flow data for other services was available and could be included.

Sectoral Flows - First Class Mail				
Send \ Receive	Business	Government	Household	Total
Business	26%	--- (<1%)	47%	73%
Government	1%	2%	3%	6%
Household	6%	1%	14%	21%
Total	33%	3%	64%	100%
Source: Study done for the Kappel Commission (President's Commission on Postal Organization), "Toward Postal Excellence", (June 1969).				

## Economic Model - Substitution of EMS for First Class Mail

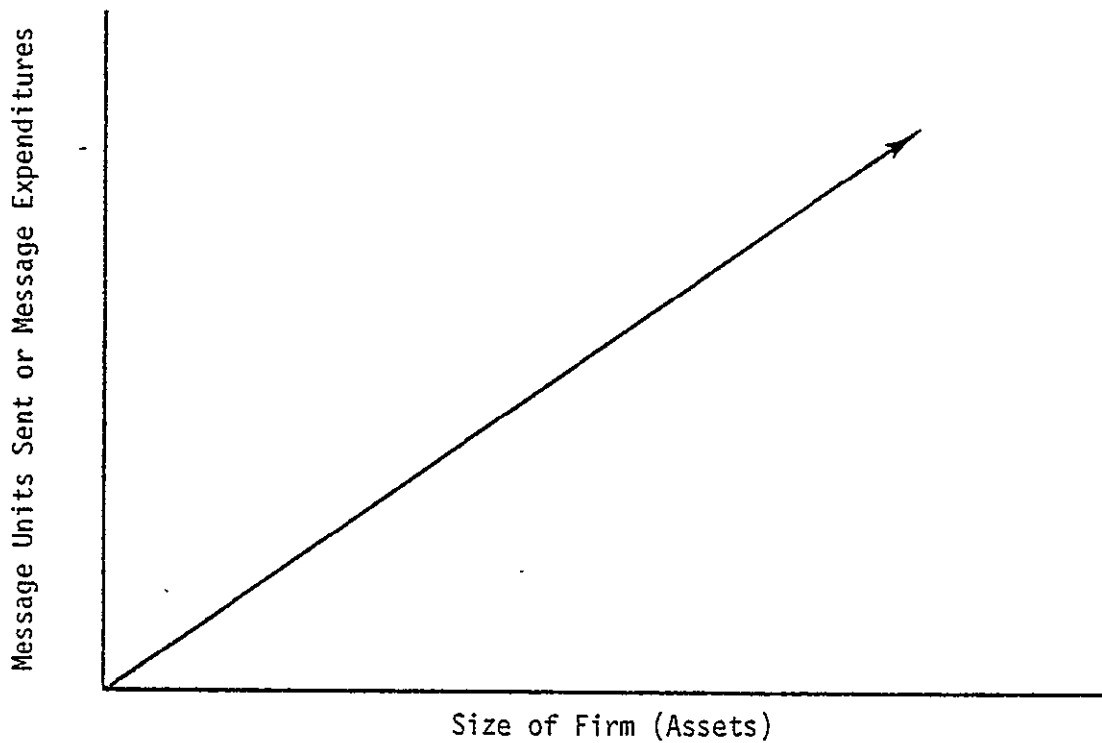
### Assumptions About Firms

Assumption 1: Large firms send on the average and in the aggregate more mail than small firms. It is assumed that the quantity of mail sent by a firm is proportional to its asset size.

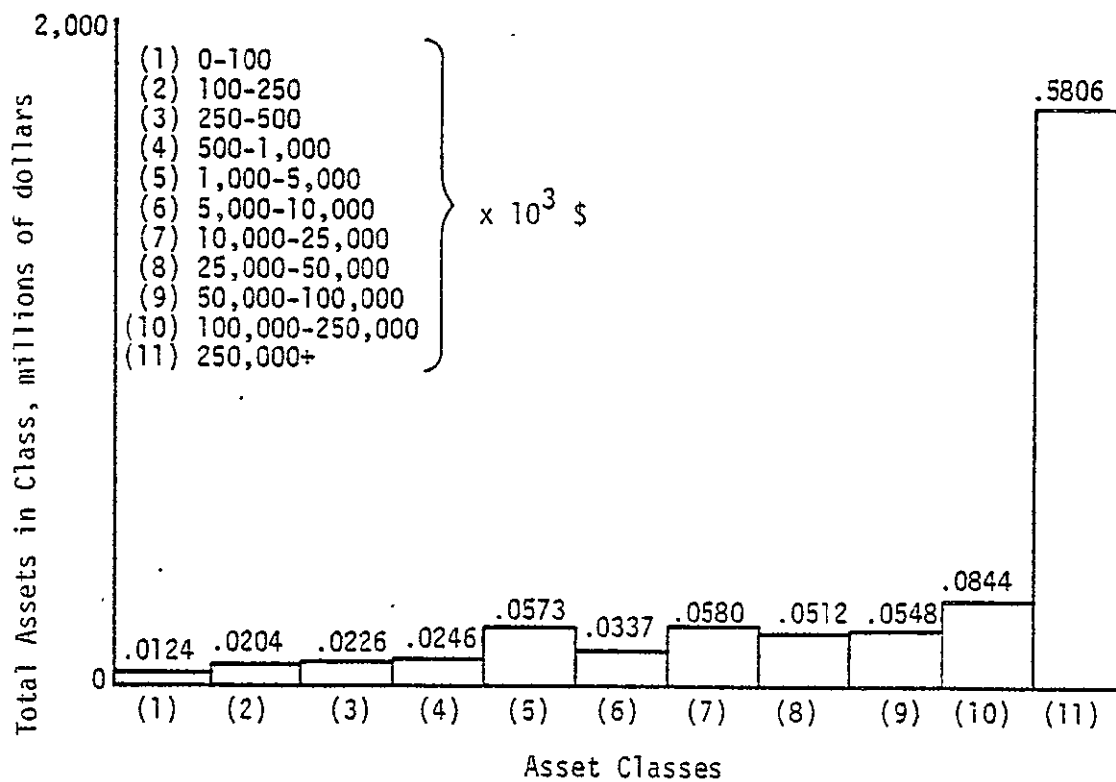
Assumption 2: Firms send mail to themselves, to other firms of the same size and to firms larger and smaller. The amount of mail sent by a firm in a particular size class to firms in a different size class is assumed to depend on both the number and size of firms in the class.

Assumption 3: The amount of a firm's electronically transmittable mail that can be sent via EMS will depend on the number and size of the other firms who use the system.

Assumption 4: In deciding whether or not to purchase the EMS, the firm will evaluate the proportion of its mail which it expects to send via EMS, and compare current expenditures to the alternative cost of using the EMS system. The firm will demand the EMS if it can save (or not lose) any money in doing so.



Messages Sent Versus Size of Firm



Proportion of Mail Sent by Firms  
Having Different Levels of Assets

### Assumptions About System Capabilities

Assumption 5: The firm will be able to select that input/output combination which best meets its needs.

Assumption 6: The system will be available for transmission and reception for 11 hours each working day.

Assumption 7: The user terminal has a certain fixed transmission capability which cannot be exceeded. According to the General Dynamics study, the maximum tolerable feed-in rate is 5 seconds per page. It is assumed, then, that the maximum number of 2-page message units which can be transmitted by a single terminal in an hour is 360. Varying the peak-to-average load ratio yields several alternate constraints on the capabilities of the user terminal.

## Peak-to-Average Load Ratios: Constraints on Terminal Capabilities

1/1      6 letters/minute  
          360 letters/hour  
          3,960 letters/day  
          1,069,200 letters/year

2/1      3 letters/minute  
          180 letters/hour  
          1,980 letters/day  
          534,600 letters/year

3/1      2 letters/minute  
          120 letters/hour  
          1,320 letters/day  
          356,400 letters/year

6/1      1 letter/minute  
          60 letters/hour  
          660 letters/day  
          178,200 letters/day



## Background Data

The background data used in the mathematical derivation of the demand relationship consists of the following four sets of figures:

1. The number of firms falling into each of eleven asset (size) categories,
2. The average assets of firms in each category (equals total assets in bracket÷number of firms in bracket),
3. The approximate number of pieces of electronically transmittable business mail sent by firms in each bracket, and
4. Current expenditures on this portion of the mail.

The data for Parts 1 and 2 were taken from the Internal Revenue Service's 1971 Federal Corporate Income Tax records. Part 3 was derived (using the linearity assumption mentioned above) from data on total potential demand for EMS given in a 1974 Arthur D. Little study.\* Part 4 was derived from Part 3 with the assumption that firms are currently spending 13¢ to send each unit of mail.

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\*"A Survey of Technologies Applicable to Electronic Mail Handling Systems", Arthur D. Little Company, August 1974.

Demand Model: Background Data

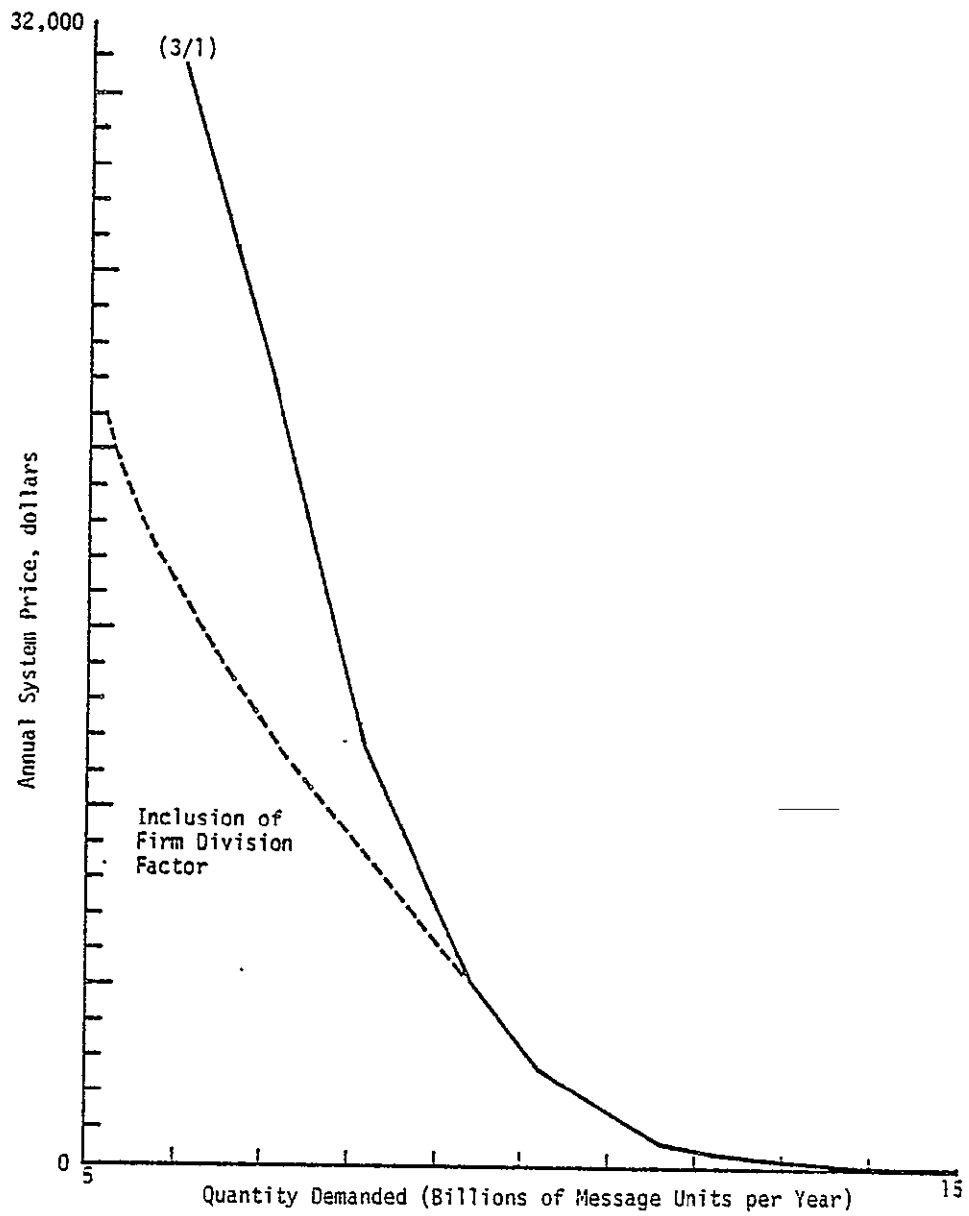
<u>Assets, \$1000</u>	<u>No. of firms</u>	<u>Asset Average, \$1000</u>
0-100	1,082,690	29.698
100-250	387,327	138.793
250-500	190,337	313.057
500-1000	101,521	639.737
1000-5000	77,423	1,948.969
5000-10000	12,655	7,019.945
10000-25000	9,850	15,510.698
25000-50000	3,890	34,706.013
50000-100000	2,080	69,477.996
100000-250000	1,435	154,962.093
250000+	1,201	1,273,819.752

<u>Assets, \$1000</u>	<u>Elec. Trans. Business Message Units</u>	<u>Average</u>	<u>Expenditures, dollars</u>	<u>Average, dollars</u>
0-100	0-468	154	0-60.85	20.06
100-250	468-1,171	721	60.85-152.11	93.68
250-500	1,171-2,340	1,627	152.11-304.23	211.45
500-1000	2,340-4,681	3,324	304.23-608.47	432.35
1000-5000	4,681-23,402	10,128	608.47-3,042.32	1,316.63
5000-10000	23,402-46,805	36,553	3,042.32-6,084.65	4,751.91
10000-25000	46,805-117,012	80,597	6,084.65-15,211.63	10,477.67
25000-50000	117,012-234,025	180,341	15,211.63-30,423.25	23,444.35
50000-100000	234,025-486,050	361,024	30,423.25-60,846.50	46,933.24
100000-250000	486,050-1,170,125	805,223	60,846.50-152,116.25	104,678.98
250000+	1,170,125+	6,619,087	152,116.25+	860,481.25

## Results

The demand curve for Electronic Message Service is derived from the assumptions enumerated above, and the data on the preceding page. The basic methodology involves determining which firms will participate in the system at a given price or cost of service, and then estimating the number of messages sent between these firms. The resulting demand curve can be expressed in two ways: units of mail sent by the EMS versus price (cost of service) or bit-rate demanded versus price (cost of service). (A figure of 65 kilobits per message unit was taken from the Arthur D. Little study.)

A sensitivity analysis on the peak-to-average load ratio shows that the smaller the ratio, the steeper the upper tail of the demand curve. This is logical in economic terms, since if a firm chooses to load its user terminal(s) very heavily and risk queuing at peak times, the price it would be willing to pay for each terminal would be higher than if a larger peak-to-average load ratio were selected, to allow for more idle time. In order to show the effects of loading on demand, the assumption was made that all firms would select approximately the same peak-to-average load ratio. In actual fact, the ratio selected by firms would differ according to the nature of their profit-making activities.



Demand Curve for Electronic Message Service

## Substitution for Other Communications Services

One of the likely effects which an EMS would have on overall interpersonal communications is that of substitution for non-hard-copy services. If an EMS was able to transmit messages, within, for example, an hour's time, there would certainly be a tendency to send certain messages through the EMS in lieu of making telephone calls (particularly long-distance) and arranging face-to-face meetings. Since a significant portion of business communications are of the information-exchange type, some substitution of EMS for verbal communications is highly likely. The full extent of such substitution cannot be determined, however, from existing communications patterns.

## Quality Considerations

A U.S. Postal Service study done in 1975\* produced a ranking of 12 attributes of mail service which might be considered important to business consumers. Notably, consistency is ranked first, while absolute speed is only third. A comparison of this ranking against a list of attributes which an EMS is likely to have (and those it is not likely to have) leads to the conclusion that a significant improvement in consistency, reliability and speed would very certainly have an important impact on the message-sending market. The effect would manifest itself in an outward shift of the demand curve, implying that at any given price there will be a certain amount of demand emanating from businesses who could minimize costs by using the current system, but who consider the improved quality worth an extra expenditure. Again, the full impact of the improvement in quality cannot be measured at this time, although it has been estimated that from two to five percent of business mail is urgent enough to be worth an increased cost.

\*"The Ranking of Selected Characteristics in Terms of Their Importance for Service Used and Items Sent by the Service", USPS Market Research Division, January 1975.

## Message Services - Ranking of Desirable Attributes

Consistency

Delivery by a certain time

Absolute speed

Assured protection against loss or theft

Undamaged delivery

Forwarding or return if address incorrect

Proof of arrival at destination

Delivery at a certain time

Traceability

Security (confidentiality of contents)

Cost

Ability to insure contents

### EMS Attributes

(+)

Consistency

Reliability

Speed

(-)

Ability to insure contents

Security

Traceability

## Caveats, Comments, Biases, Trends

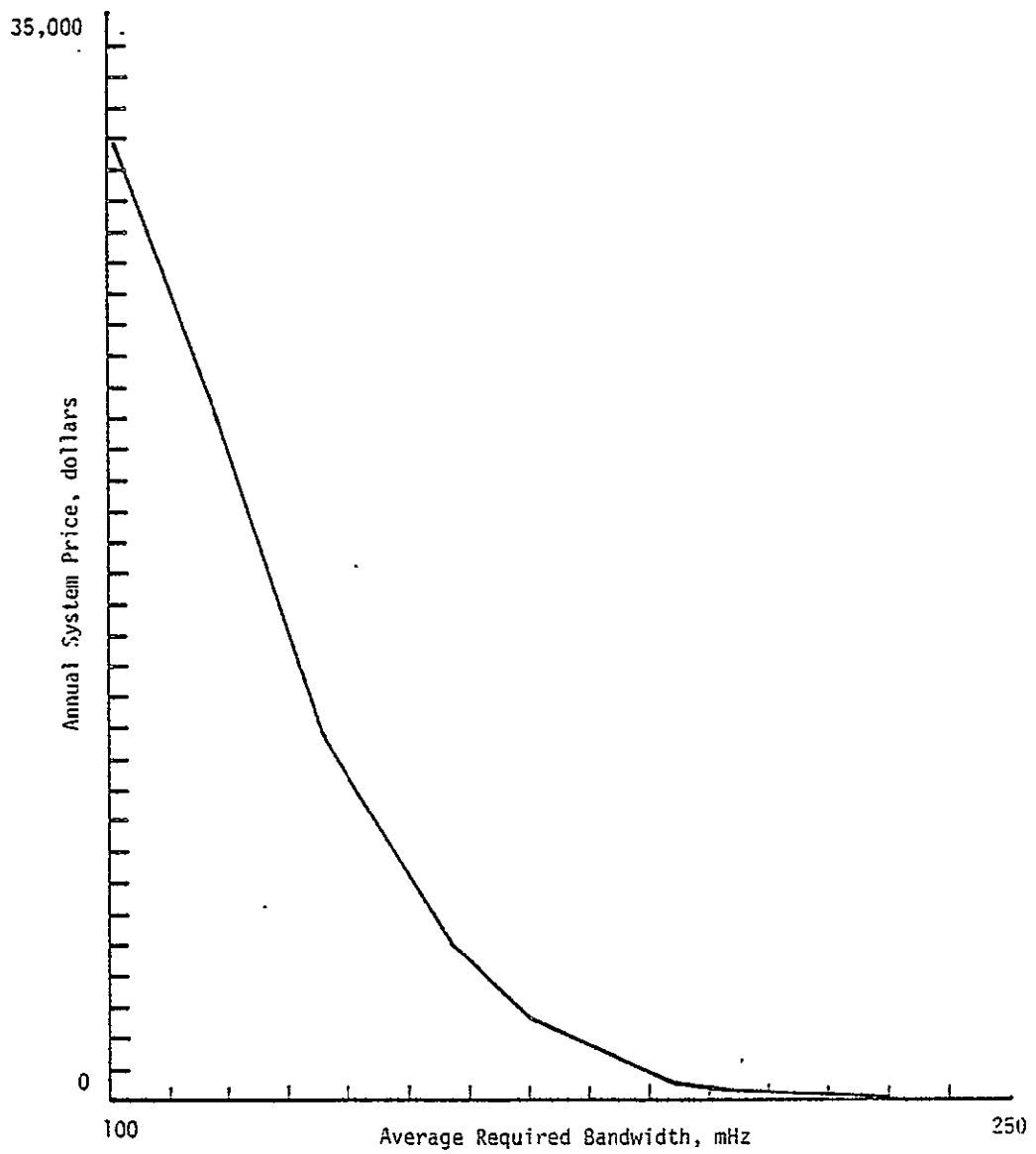
### Firm Divisions

One factor which could not be taken into account due to lack of data was the effect of firm divisions. At a certain point in the size scale, firms begin to have multiple branches. By assuming that mail services demanded is strictly proportional to asset size, the current mail expenditures of such firms are probably being understated. At the same time, in terms of the EMS system, the number of transmit/receive capabilities needed by each firm for its many branches is also underestimated. The price that the firm would therefore be willing to pay for a single capability would be lower than what would be implied by its overall size. The nature of the problem suggests, however, that the net effect would lead to a demand curve that would actually be flatter in the upper tail than shown.

### Elasticity and Nonsubstitution Demand

The demand curve shown is the result of a substitution model based on current message-sending practices and expenditures. It might be argued that an additional demand increment would be generated whenever the price of the new system is below current costs for any firm or group of firms. In other words, those firms will send more mail than they are currently, because of the lower price.

This effect is not considered to be significant in the case of an EMS for the following reason: For a firm, message-sending is tied very strongly to profit-making activity. A firm will not significantly cut back on or increase its message-sending in response to a price change, unless its profit-making activity grows or slows accordingly. The U.S. Postal Service's finding of a very low price elasticity (in the vicinity of .37) for first class mail bear out this conclusion.



Demand Curve for Electronic Message Service



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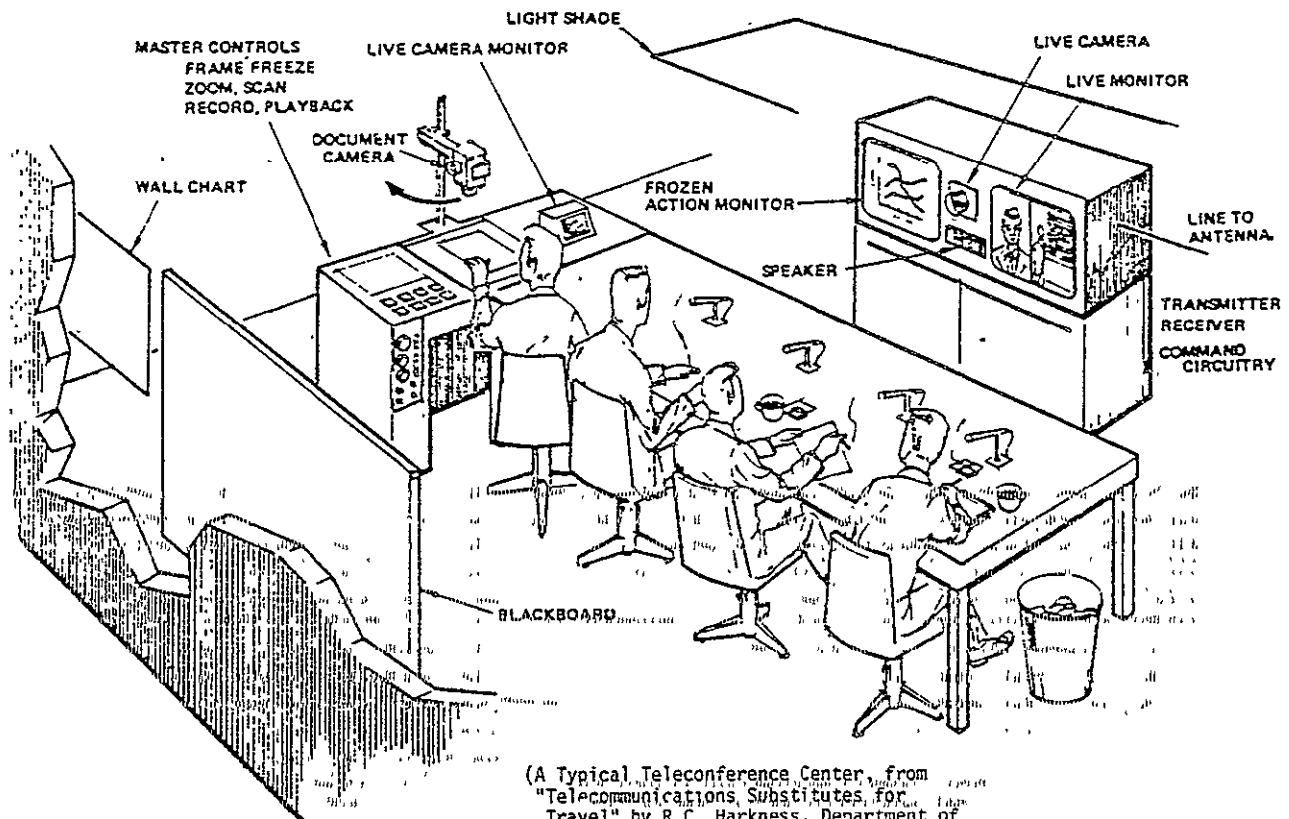
### Conclusions - Demand for Electronic Message Service

- Most likely substitution area: Business Messages sent via 1st class mail and airmail
- Total potential substitution demand: Approximately 13.5 billion message units per year
- Implied Average Bandwidth: Approximately 165 mHz
- Range of substitution Demand: 5 billion units sent per year at annual system price of \$20,000 - \$25,000; 13 billion units or more sent at price of \$100 or less
- Implied average bandwidth range: 80 mHz to 160 mHz
- Price elasticity of demand: Likely to be low because business message-sending strongly tied to profit-making activities
- Inclusion of non-mail substitution effects and quality considerations in demand model would enlarge predicted demand at all price levels

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## The Demand for Teleconferencing Services



(A Typical Teleconference Center, from  
"Telecommunications Substitutes for  
Travel" by R.C. Harkness, Department of  
of Commerce, December 1973)

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## Introduction

Communication and transportation share a unique and close relationship. There is good reason for this close association. Both activities are avenues by which an individual or a group can extend the boundaries of its environment in order to share experiences with others. Historically these two industries have followed parallel paths. Increases in transportation facilities have been mirrored by increases in communication facilities. It seems clear that the ability to communicate over large distances has necessitated new travel, just as travel has led to additional communication, in an ascending spiral of contacts.

The following pages are concerned with estimating the demand function (i.e., required bandwidth vs. the price of service) for teleconferencing services which might substitute for travel. Only the possibility of substitution for business related travel is considered. The question of whether teleconferencing can offer an acceptable substitute to travel is fraught with difficulty in analysis since so many variables intervene in the decision to make or to replace a business trip. The question of substitutability of a teleconference for travel implies the substitutability of a teleconference for a conference. A conference is a face-to-face meeting of two or more individuals to participate in an interactive interchange of views on subjects of interest to some or all of the individuals. A teleconference is a conference in which the participants interact via a communication link in lieu of a face-to-face meeting. However, a face-to-face meeting between non-acquaintances may often be fruitful.

## Introduction

### Telecommunications: A Substitute for Travel

- A Conference Implies Travel.
- A Teleconference Implies Substituting Telecommunications For Travel

### Rationale For Estimating Telecommunications Demand Function

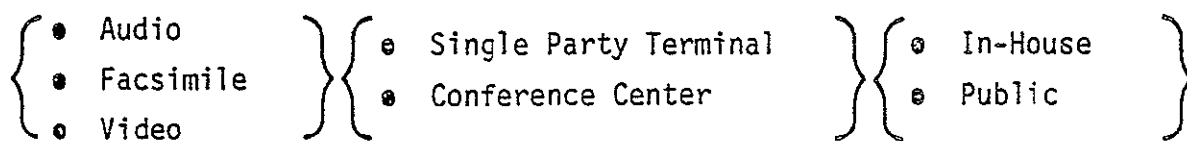
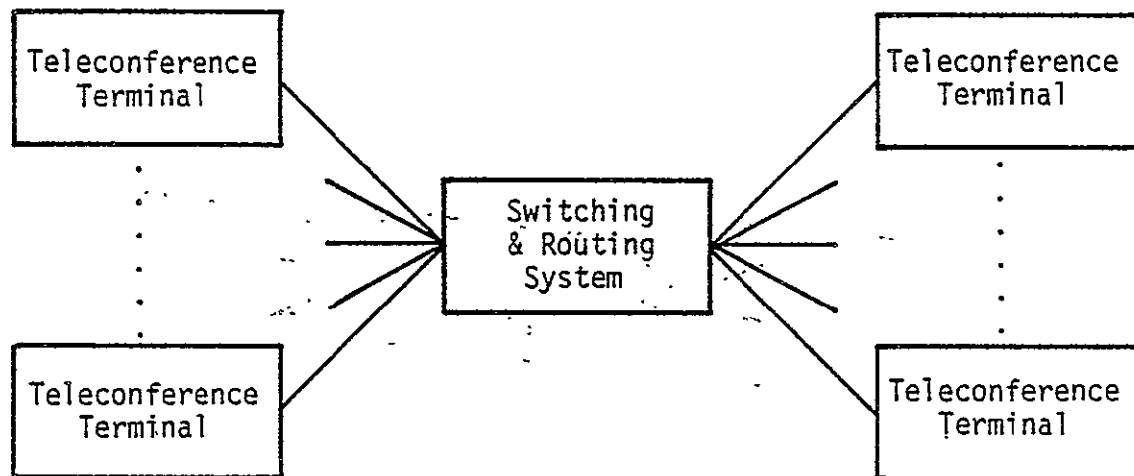
- Conferences Are Business Related.
- Telecommunications May Substitute For Some Business Related Travel.
- The Travel Foregone Is Related To The Form And Cost Of The Telecommunications Service.
  - Audio
  - Audio + Facsimile
  - Audio + Visual + Facsimile
  - Computer (Store And Forward Message System)

## Teleconference System Concept

There are many forms of possible teleconferencing services. These include audio, audio plus facsimile, audio plus visual plus facsimile, and computer store and forward message systems. Terminal configurations include single party terminals and multi-party terminals (conference centers) and may be available for in-house or public use. The applicability and specific form of these services and terminals for substituting for different types of conferences is an area of great uncertainty. Experimentation to date has indicated\* that in communication, uncertainty is uncomfortable and that efforts will be made to eliminate it. The concept of uncertainty can be applied both to the relationship between people and to the inherent characteristics of communication systems as they relate to the information they transmit. It follows that between individuals, becoming acquainted reduces uncertainty. An audio communications system can be said to impose more uncertainty on a contact than a face-to-face meeting because it does not provide any visual information. This suggests that there is some overall level of uncertainty which is optimal. For example, where the communications system involves higher uncertainty (audio) then the individuals using it will be better off if they are acquainted (have low interpersonal uncertainty) than otherwise. It is also possible that where uncertainty between people is low, a face-to-face meeting may be unnecessary.

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\* Kohl, K., T.G. Newman, Jr., and J.F. Tomey, Facilitating Organizational Decentralization Through Teleconferencing, IEEE Transactions on Communication, Vol. COM-23, No. 10, October 1975.



Teleconference System Concept



## Video Teleconferencing Systems - Usage Characteristics

The specific teleconference terminal design, the mode of available communication service (i.e., audio, facsimile, video and their combinations), the form of available service (i.e., in-house or public), the specific teleconference applications considered, and the current cost of communications services has had a major effect upon the current and near term role of teleconferencing. Current audio and video teleconferencing usage is summarized in the accompanying tables. The variability of results is apparently the result of the particular application for which teleconferencing has been employed, the particular hardware configuration (for example, it has been demonstrated\* that stereo systems are much preferred to monoral systems for group audio teleconferences), the previous experience of the audience with teleconferencing, the communications service cost, the public or private (in-house or for public use) nature of the system, etc. Many, but not all of the audio systems, are supported by facsimile transmissions. Very positive results have been obtained by NASA\*\* and by Bell Labs. The Bell Labs experience+ with video teleconferencing indicates that about 50 percent of the users would prefer to use teleconferencing rather than travel 15 miles or a half hour of driving for a face-to-face conference. Ninety-one percent would use it rather than travel 50 miles or an hour and a half.

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\* Ibid

\*\* Connors, M.M., G. Lindsey, R.H. Miller, The NASA Teleconferencing System: An Evaluation, NASA, May 1976.

Duncanson, J.P., and A.D. Williams, Video Conferencing: Reactions of Users, Human Factors, Vol. 15, October 1973.

## Video Teleconferencing Systems - Usage characteristics \*

Video Systems	Organizational Level	Organizational Function	Meeting Frequency	Meeting Duration, hrs	No. of Participants	Meeting Type **	Status
Bell Canada	mid-upper management	managerial, staff	in-house, about 1/day	2.3 (ave.)	3-6	1-3	operational in house
Bell Laboratories	tech. staff to tech. dir.	management, research	about 2-4/week	2.1 (ave.)	3-6	1-3, 7	operational
Confravision (U.K.)	senior mgt.	managerial, staff	modest usage	1-2	6-8	1-3	operational
Confravision (Europe)	senior mgt.	managerial, staff	very little so far	n.a.	n.a.	1-3	operational
AT&T Picturephone Meeting Service	various	various	in-house, modest; public, very modest	1-2	4-6	1-3	operational
First National City Bank	senior mgt.	money market management	out of service <sup>†</sup>	1-3	3-6	1 mostly	out of service
Bankers Trust Company	senior mgt.	money market management	out of service <sup>††</sup>	1-3	3-6	1 mostly	out of service
Australian Post Office	various	managerial, staff, research	modest usage	1-2	6	1-7	operational
Dow Chemical	tech. staff, senior mgt.	research administration	1-3/week	1	3-6	1,2,7	operational
New York Telephone	managerial staff	managerial, staff	very modest usage	1-2	n.a.	1-3	operational
Nippon T&T (Japan)	senior mgt.	research, administration	n.a.	2	4-6	n.a.	operational
Metropolitan Regional Council	clerks to executives	training, inter-govt. comm.	30 hours/week	1	10-100	5 mostly	operational

\* Extracted from Hough, R.W., Teleconferencing Systems: A State of the Art Survey and Preliminary Analysis, Stanford Research Institute, May 1976.

\*\* (1) Routine business meetings, (2) informal information exchange, (3) urgent meetings, (4) meetings prior to face-to-face meetings, (5) teaching, training or instruction, (6) sale presentations, (7) research.

<sup>†</sup> Very heavy, at an average of 50 meetings per week, when operational

<sup>††</sup> Reasonably constant at about 3-5 meetings per week when operational.

## Audio Usage Characteristics

The NASA experience with audio plus facsimile indicates that teleconferencing is appropriate under some conditions, face-to-face meetings under others. The nature of the meeting is the prime determinant of the mode choice. It was found that for meetings of routine matters, teleconferencing is the preferred mode. If the meeting is important and complex (especially involving negotiations), face-to-face is the preferred mode. Teleconference participants also placed high value on their time and competing commitments and on saving the costs of travel (this seems to be particularly true when tight constraints are placed upon travel budgets). It was found that those who made the most use of teleconferencing tended to shift travel allocations away from project endeavors and towards meeting travel, a finding supportive of a partial substitution hypothesis.

Teleconference terminals which have been investigated cover the range of individual terminals (for example, AT&T's Picturephone) to large specially designed conference centers.

## Audio Usage Characteristics\*

Audio Systems	Organizational Level	Organizational Function	Meeting Frequency	Meeting Duration ,hrs	No. of Participants	Meeting Type **	Status
Remote Meeting Table (U.K.)	mid to senior level mgt.	civil servants	1-3/week	2	3-6	1-4	operational
NASA	mid to senior level mgt.	admin., proj. mgt., research	20-30/week	2-3	32 (ave.)	1-3,7	operational
Univ. of Quebec (Canada)	various	admin., teaching	3-4/week	1-2	6-10	1-4	operational
Department of Communications (Canada)	mid-senior level	mgt., staff	1-2/week	1-2	6-10	1,2	operational
Department of Indian & Northern Affairs (Canada)	mid-senior level	mgt., staff	1-2/week	1-2	6	1,2	operational
General Services Admin.	n.a.	n.a.	n.a.	1	10-20	+	operational
New Rural Society Project (Union Trust Company)	senior level mgt.	mgt. committee	3-5/week	2-3	8-12	1,2	operational
General Electric	staff and mgt.	proj. staff mostly	8/week	1-2	4-8	1-3,7	operational
Bank of America	senior level mgt.	high level committee	10-15/week	2-4	8-16	1,2	operational

\*Extracted from Hough, R.W., Teleconferencing Systems: A State of the Art Survey and Preliminary Analysis, Stanford Research Institute, May 1976.

\*\* (1) routine business meetings, (2) informal information exchange, (3) urgent meetings, (4) meetings prior to face-to-face meetings, (5) teaching, training or instruction, (6) sale presentations, (7) research.

+ Most meetings to date have been for demonstration and to "show-off the System".

## Procedure for Estimating the Demand Curve

The basic thesis for establishing the teleconference demand curve is that teleconferencing can and will be substituted for business related travel. It is assumed that

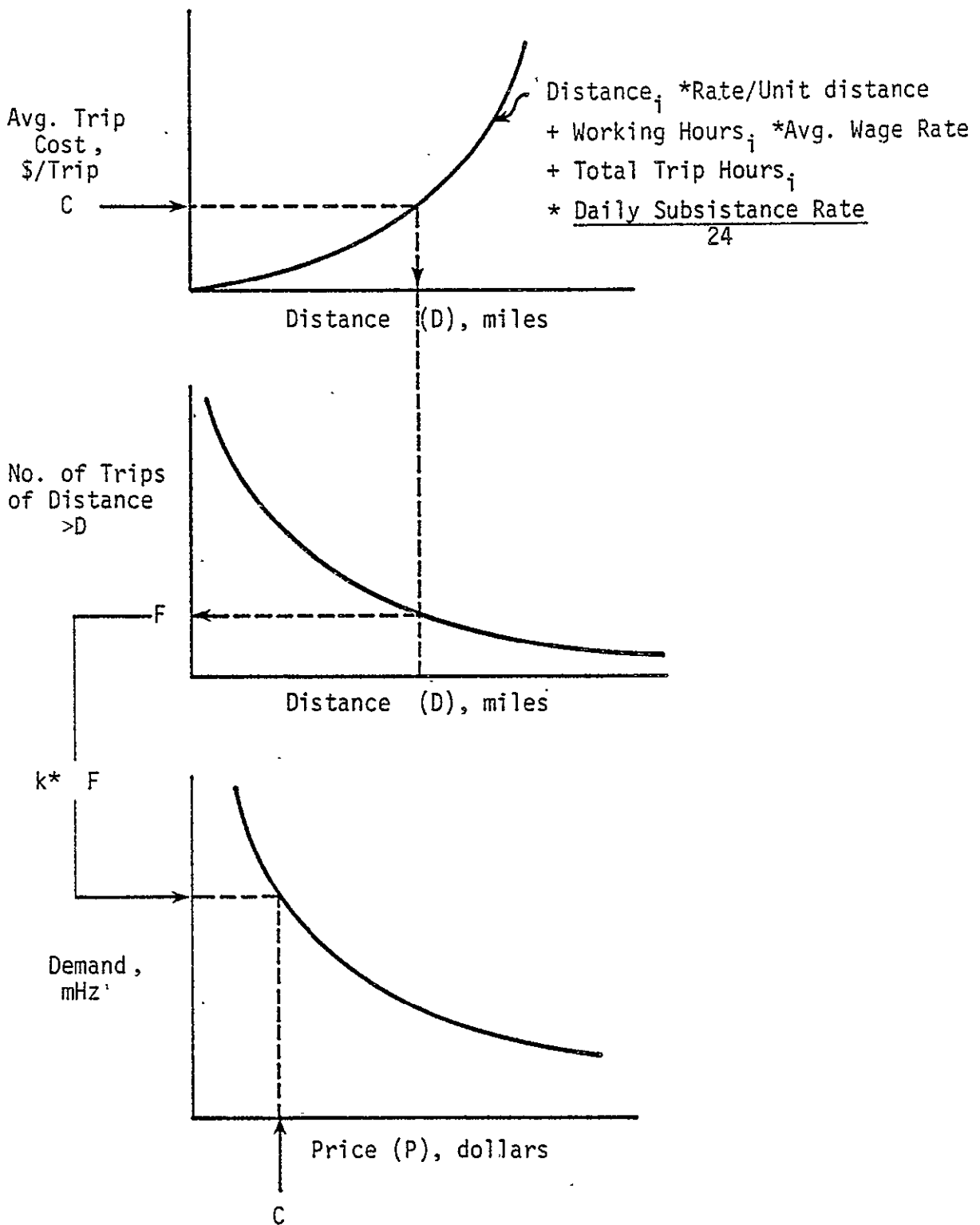
$$\text{Travel Cost} + \text{Teleconference Cost} = K$$

where K is the annual cost of business related travel without the availability of a teleconferencing capability. History indicates that the value of K is a function of time and has increased significantly during the past decade. It will probably continue to increase in the future.

It is assumed that teleconferences will be substituted for business related travel if (a) the teleconference can satisfy the meeting requirements and therefore is functionally substitutable for the travel, and (b) the cost associated with the teleconference is less than the cost of travel to attend the conference. The indicated teleconference demand curve estimation procedure is based upon (a) establishing the current average business trip cost (limited to air travel in the current analysis) in terms of distance, and (b) establishing the number of business trips in terms of distance\* (actually this is considered also as a function of trip type). Once this has been accomplished a specific trip cost, C, is selected. This results in (a) the number of business trips, F, which could be foregone if the teleconference cost or price were less than C, and (b) the time-bandwidth product which is associated with foregoing F trips. The determination of the required bandwidth necessitated the estimation of the teleconference type per meeting or trip type, the duration of the teleconference, the number of facsimile pages, etc. This establishes a point on the demand curve. Varying the cost, C, (price, P) yields the desired demand function.

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\*The number of business trips in the future (without the availability of teleconferencing) is conservatively assumed equal to that of the present.



Procedure for Establishment of Demand Curve

## Trip Distance and Cost

According to the U.S. Travel Data Center's ~~Yearly~~ Travel Survey for 1974, approximately 90 million business trips were taken that year of which approximately one-third utilized air transportation. Assuming that most ~~trips~~ in excess of 100 miles used air transportation, the relationship of business trips taken (using air transportation) to distance traveled is illustrated. There appears to exist an approximate inverse exponential relationship between number of trips taken and distance traveled. More than 50 percent of all business trips taken were less than 300 miles in length (one-way distance), while 11 percent were in excess of 1000 miles (one-way distance).

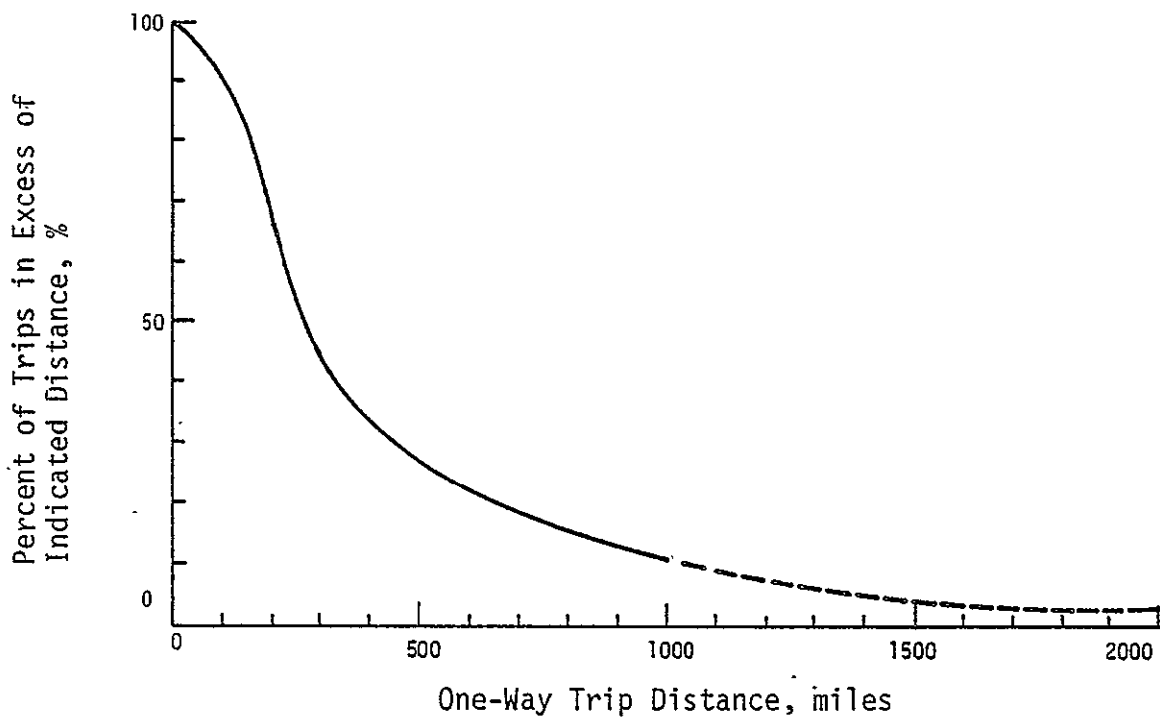
The cost of a business trip can be divided into "out-of-pocket" costs and "working-time" costs. Out-of-pocket costs include long-haul transportation costs, subsistence, and ground transportation costs. Working-time costs include direct wages and overhead. Therefore, the total trip cost can be computed as follows:

$$\begin{aligned} \text{Total Trip Cost} = & (2 \times \text{One-way Trip Distance} \times \text{Cost Per Mile}) \\ & + (\text{Trip Duration} \times \text{Daily Subsistence Rate}) \\ & + (\text{Trip Duration} \times \text{Daily Ground Transportation Rate}) \\ & + (\text{Working Hours} \times \text{Wage Rate}) \times (1 + \text{Overhead Rate}) \end{aligned}$$

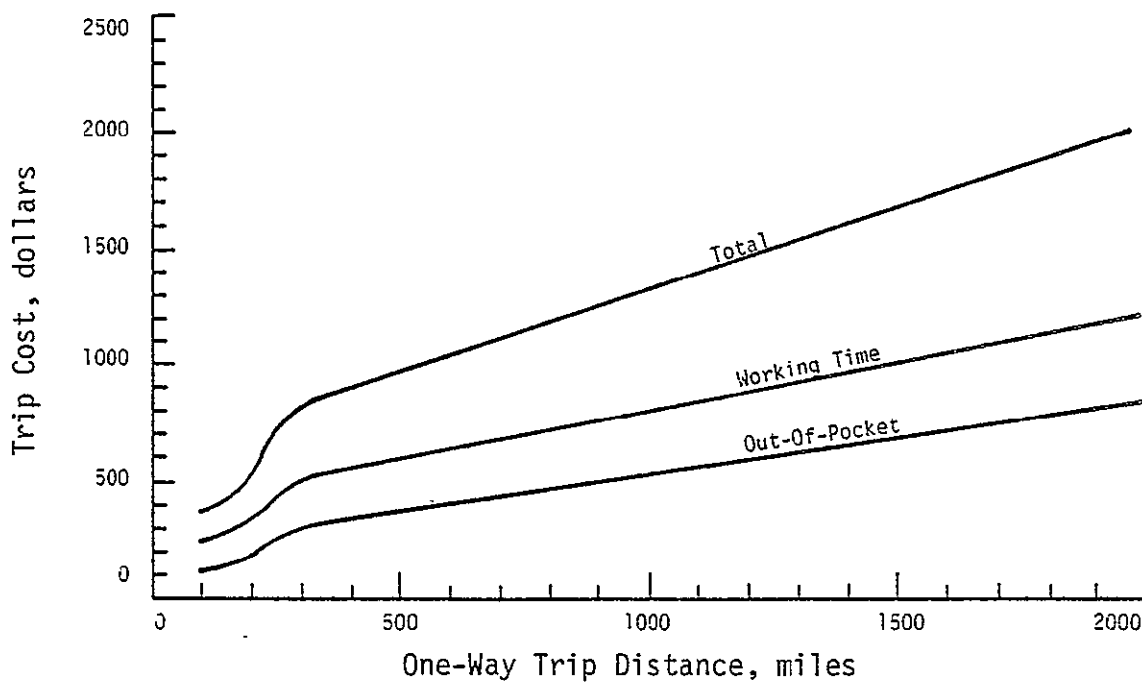
Total trip cost, as well as its two component parts, as a function of one-way trip distance is illustrated. It should be noted that the cost per mile, trip duration, and working hours are functions of the one-way trip distance. Travel (both long-haul and ground) costs were derived from the Official Airline Guide, Volumes 1 and 2, November 1, 1976. The long-haul cost ranges from approximately 8¢/mile for 2000 miles to 20¢/mile for 150 miles. An average ground transportation rate of \$26/day was estimated. Trip duration, according to the U.S. Travel Data Center's Yearly Travel Survey for 1974, is related to trip distance ranging from approximately 1.2 nights for a 100 mile (one-way) trip to 6.8 nights for a 2000 mile (one-way) trip. These have been estimated as corresponding to trip durations of 1.75 and 7 days, respectively, and 14 and 56 working hours, respectively. The average wage rate of travelers was estimated\* as corresponding to a salary level of \$20,000 per year. Finally, an overhead rate of 100 percent was assumed.

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\*Based upon data presented in report entitled "Consumer Knowledge, Belief, and Preferences Regarding Air Fares", prepared by Gallup, Inc. for American Express, August 13, 1975.



Percent of Business Trips (Air Travel) in Terms of Distance



Business Trip Cost vs. Distance



## Percent of Business Trips Which May be Foregone

The type of business traveler and the associated percentage of business travel is indicated\* in the accompanying table. The substitutability of teleconferencing has been found to be a function of the form of travel. It is anticipated that teleconferencing will find little or no substitutability for trips taken by sales and clerical personnel and by skilled craftsmen. It is anticipated that teleconferencing will be best suited for substituting for trips taken by professionals and by executive and management personnel. It has been estimated that perhaps 50 percent of their trips might be functionally substitutable by audio/facsimile teleconferencing\*\* yielding a total of 26.5 percent of business trips functionally substitutable by teleconferencing. It should be noted that these estimates may be somewhat on the optimistic side since travel is only occasionally undertaken for the purpose of interaction with a single other person. In fact, it has been found that about 50 percent of the meetings involved eight or more other people. This suggests that it might be difficult to simply substitute telecommunications for long distance physical travel unless convenient conference terminals were available.

It should be noted that teleconferencing will require some changes in custom, notably with respect to who does the traveling. It has been customary in many, though not all instances, that the person seeking knowledge travels to the person providing the knowledge. If individuals do not have teleconference terminals but only teleconference centers are available, then all parties must travel. This may provide a further obstacle to the growth of teleconferencing.

The demand curves being estimated are based upon trips that would have been taken but are foregone for teleconferencing. There is a demand for teleconferencing which is not related to travel but to travel which could not be taken due to budget and/or time constraints. This demand is not herein considered.

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\* Consumer Knowledge, Belief, and Preferences Regarding Air Fares, prepared by Gallup, Inc. for American Express, August 13, 1975.

\*\* This is indicated by the NASA experiences and according to K. Kohl, T.G. Newman, Jr., J.F. Tomey, Facilitating Organizational Decentralization Through Teleconferencing, IEEE Trans. on Comm., Vol. Com.-23 No. 10, October 1975.

Percent of Business Trips Which May Be Foregone (Audio/Facsimile Teleconferencing)			
Occupation of Business Travelers	Business Trips, %	Percentage of Teleconference Substitutability, %	Percentage of Trips Which may be Function- ally Foregone, %
Professional	31	50	15.5
Executive/Management	22	50	11.0
Sales	10	0	0
Clerical	5	0	0
Skilled Craftsmen	11	0	0
All Other	21	0	0
Total	100	-	26.5

## Allowable Cost Per Audio/Facsimile Teleconference Participant

The demand function for audio/facsimile teleconferencing is established in terms of the cost per participant in the teleconference. The demand is established in terms of average bandwidth (mHz) and is based upon the following:

$$\frac{\text{Cost/Participant/Teleconference} \times \text{No. of Teleconferences Required to Replace Trip}}{\text{Cost of Trip Foregone}}$$

$$\text{Average BW/Trip (Audio/Fax)} = \frac{\text{No. of Teleconferences Required to Replace Trip} \times 4\text{kHz}}{\text{No. of Participants who Would Have Traveled}}$$

$$\text{Total BW} = \frac{\text{Avg. Telecon. Duration}}{8 \text{ Hours}} \times \sum_i (\text{No. of Trips Foregone/day})_i \times (\text{Avg. BW/Trip})_i$$

where  $i$  is an index referring to distance category.

The demand function is based upon the following assumptions:

- On the average, there are five (5) participants to a teleconference who will forego travel.
- Average duration of audio/fax. teleconference is two hours\*.
- Twenty percent of teleconferences require facsimile transmissions (100 lines/inch resolution).
- Ten - Twenty pages (8 1/2" x 11") are transmitted when facsimile is required.
- Number of teleconferences required to replace a trip is directly proportional to trip duration (proportionality constant = 1.0).
- Teleconferences take place during a normal eight (8) hour work period.

These assumptions lead to the conclusion that facsimile transmissions have little impact on average bandwidth requirements.

Based upon the above, the allowable cost/participant/teleconference is indicated in the accompanying table. It should be noted that this cost is rather insensitive to distance. Therefore, since the average cost of the time spent at the teleconference is approximately \$40 (assuming 100 percent overhead and equal number of participants at other terminals), it may be concluded that in the long run all functional substitution (teleconference in lieu of travel) will take place if the cost/participant/teleconference is in the range of \$225 - \$275.

\* Experience has indicated that teleconference meetings tend to be 30-35 percent shorter than the prior face-to-face meetings.

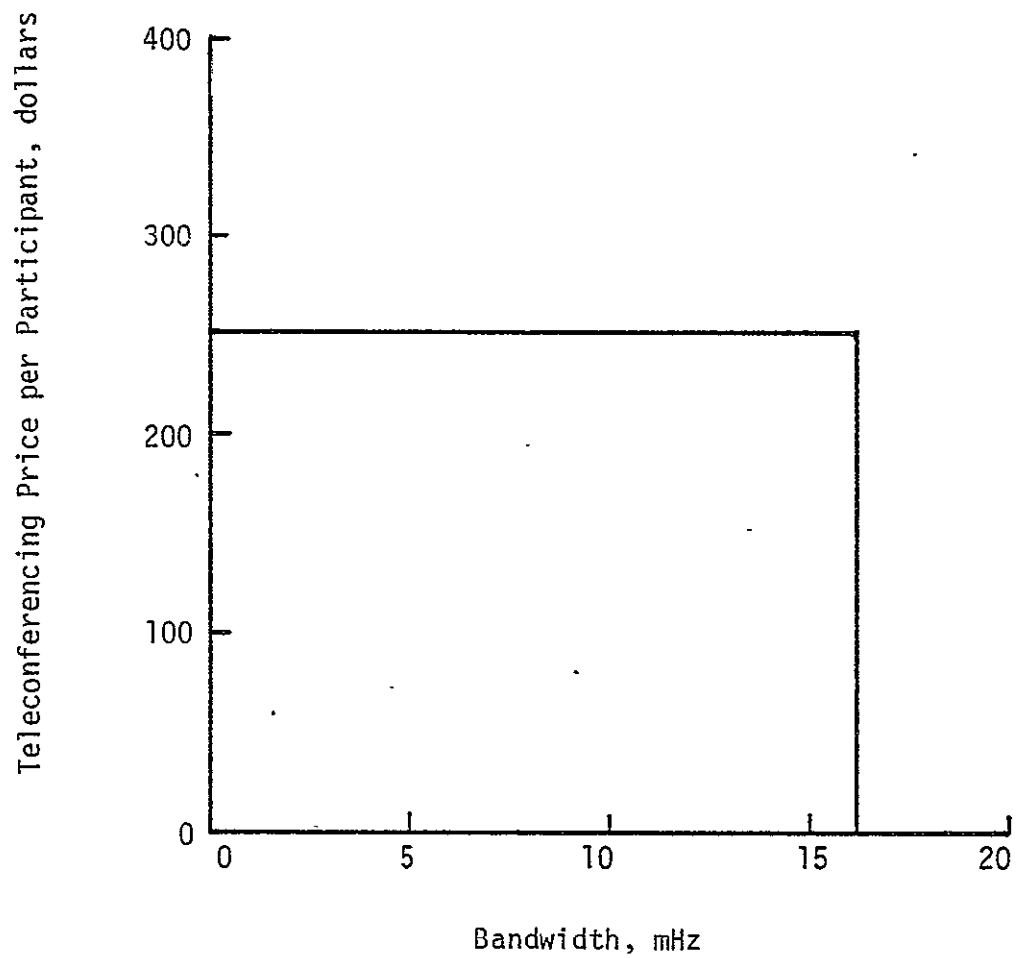
Allowable Cost Per Audio/Fax Teleconference Participant for Substitution for Travel			
One-Way Travel Distance, mi.	Trip Cost, \$	Average Trip Duration, days	Allowable Cost/Participant/ Teleconference, \$
100	350	1.2	292
200	550	2	275
300	800	2.9	280
400	925	3.2	290
600	1050	3.9	269
800	1150	4.4	261
1000	1275	4.9	260
1200	1400	5.4	259
1400	1550	5.9	262
1600	1675	6.4	262
1800	1825	6.9	264
2000	2000	7.4	270

### Demand Curve for Audio/Facsimile Teleconferencing

The demand curve for audio/facsimile teleconferencing is indicated in the accompanying figure. The demand curve represents the average bandwidth required for teleconferencing in terms of the cost or price per participant per teleconference. On the order of 16 MHz average bandwidth is required to satisfy the audio/facsimile teleconferencing demand. It should be noted that the demand is zero at price/participant/teleconference above about \$250 and is equal to 16.2 MHz below this price. This is undoubtedly not quite true since there will be some demand at higher prices and increased demand at lower prices.

In evaluating allowable cost, no consideration was given to differences in recurring and nonrecurring costs. Also, no explicit consideration was given to the time and cost of the teleconference participant's travel to attend the teleconference. Consideration has been given to the cost of time during attendance at the teleconference by the participants who would normally travel (the knowledge gatherers) and those who would not (the knowledge providers). Therefore, the teleconferencing cost is the average cost or charge (price) which would be imposed upon each of the participants by an independent organization "leasing" the teleconference terminal.

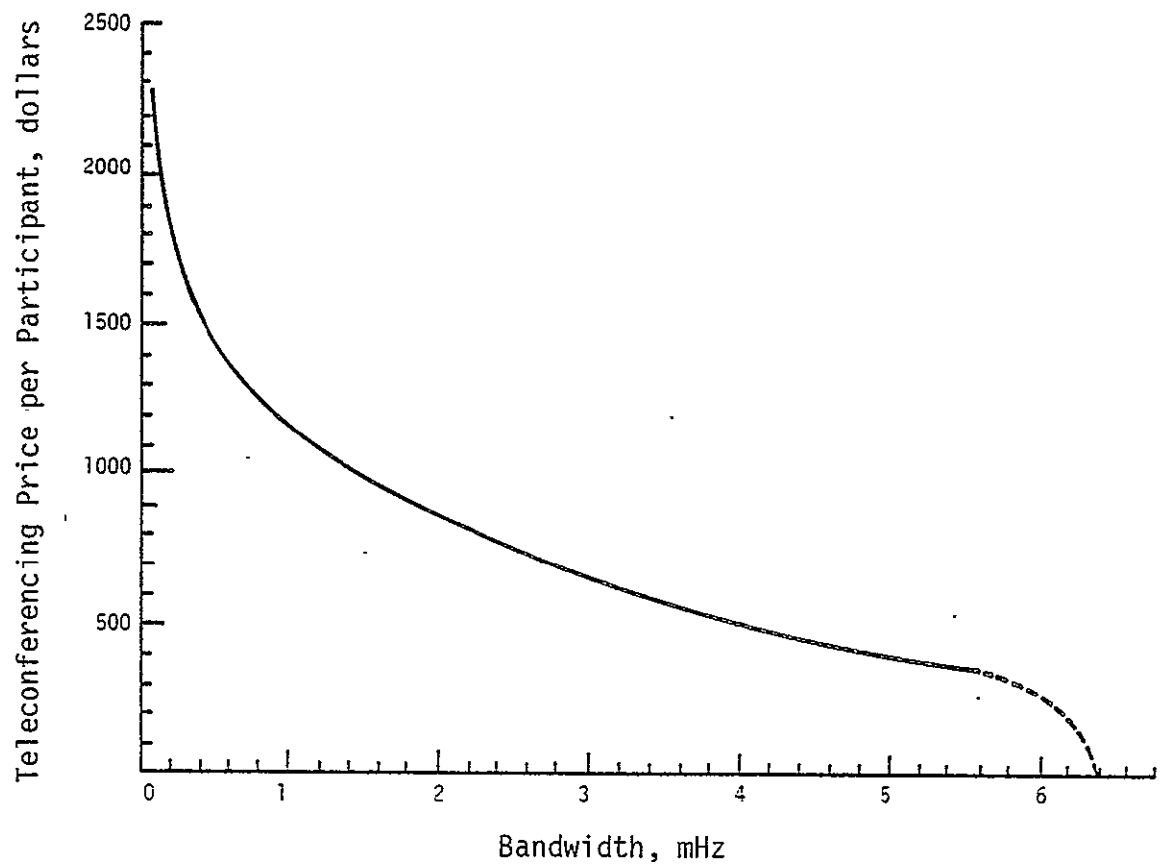
A serious limitation of the above analysis is that each trip is treated as an independent event - group trips are not considered. Their consideration would tend to reduce the demand at a cost of \$250 but would extend the demand curve to higher cost levels.



Demand Curve for Audio/Facsimile Teleconferencing  
(Number of teleconferences required proportional to  
trip duration)

### Alternative Demand Considerations

The previously depicted demand curve for audio/facsimile teleconferencing was based upon the assumption that the number of teleconferences required to forego a trip is directly proportional to trip duration. The accompanying figure illustrates the demand function for audio/facsimile teleconferencing when a single teleconference can substitute for a business trip irregardless of trip duration.



Demand Curve for Audio/Facsimile Teleconferencing  
(Number of teleconferences required independent of trip  
duration - one teleconference per trip foregone)



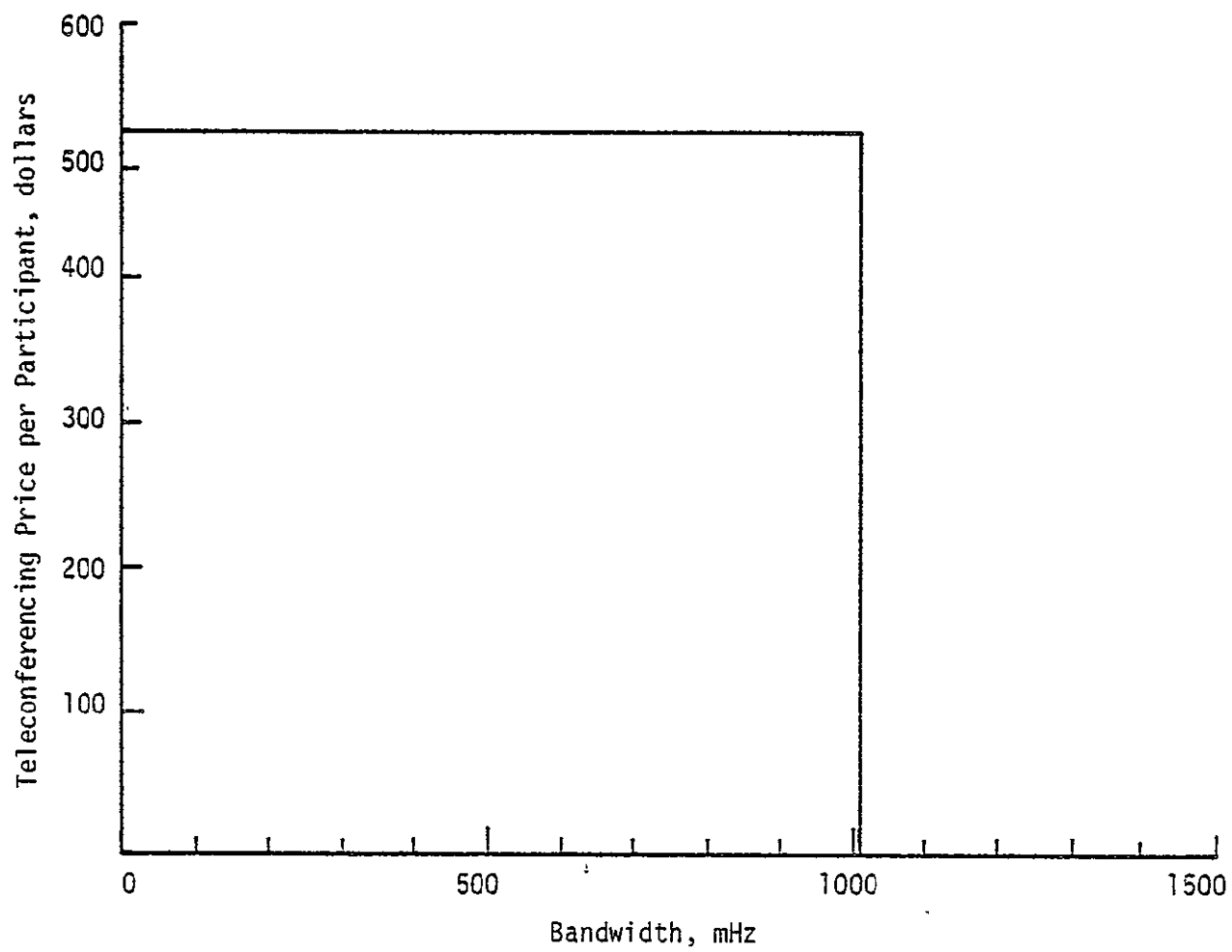
### Demand Curve for Video Teleconferencing

It is assumed that video teleconferencing will always be more expensive than audio/facsimile teleconferencing. Therefore, it is assumed that video teleconferencing will only be used to forego those business trips that could not be satisfied by audio/facsimile teleconferencing.

The demand curve may be established in the same manner as for the audio/facsimile teleconferencing, however with the following different assumptions:

- Average duration of video teleconference is one (1) hour.
- Number of teleconferences required to replace a trip is directly proportional to trip duration (proportionality constant = 0.5). This is a very subjective assessment.
- Video teleconferencing will be functionally substitutable for 10 percent more business trips than audio/facsimile teleconferencing.

The accompanying figure indicates the resulting demand curve. It should be noted that on the order of 1000 MHz are indicated as being required if the price per teleconference participant is on the order of \$500 - \$550. As in the case of estimating the demand for audio/facsimile teleconferencing, a serious methodology limitation exists in that each trip is treated as an independent event - group trips are not considered. Their consideration would tend to reduce the demand at a price of \$525 but would extend the demand curve to higher price levels.



Demand Curve for Video Teleconferencing

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## SUMMARY

- Teleconference Demand Estimates Based upon Substitution for Business Travel
- Substitutability is a Function of
  - Type of Business Travel
  - Form of Teleconference Service
  - Business Travel & Teleconference Service Cost
- Audio/Facsimile Demand
  - 10-20 mHz when Teleconference Price (Cost) per Participant  $\leq$  \$250
- Video Demand
  - 1000 mHz when Teleconference Price (Cost) per Participant  $\leq$  \$550
- Video Demand is Very Large But Very Uncertain

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SUMMARY

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### Summary

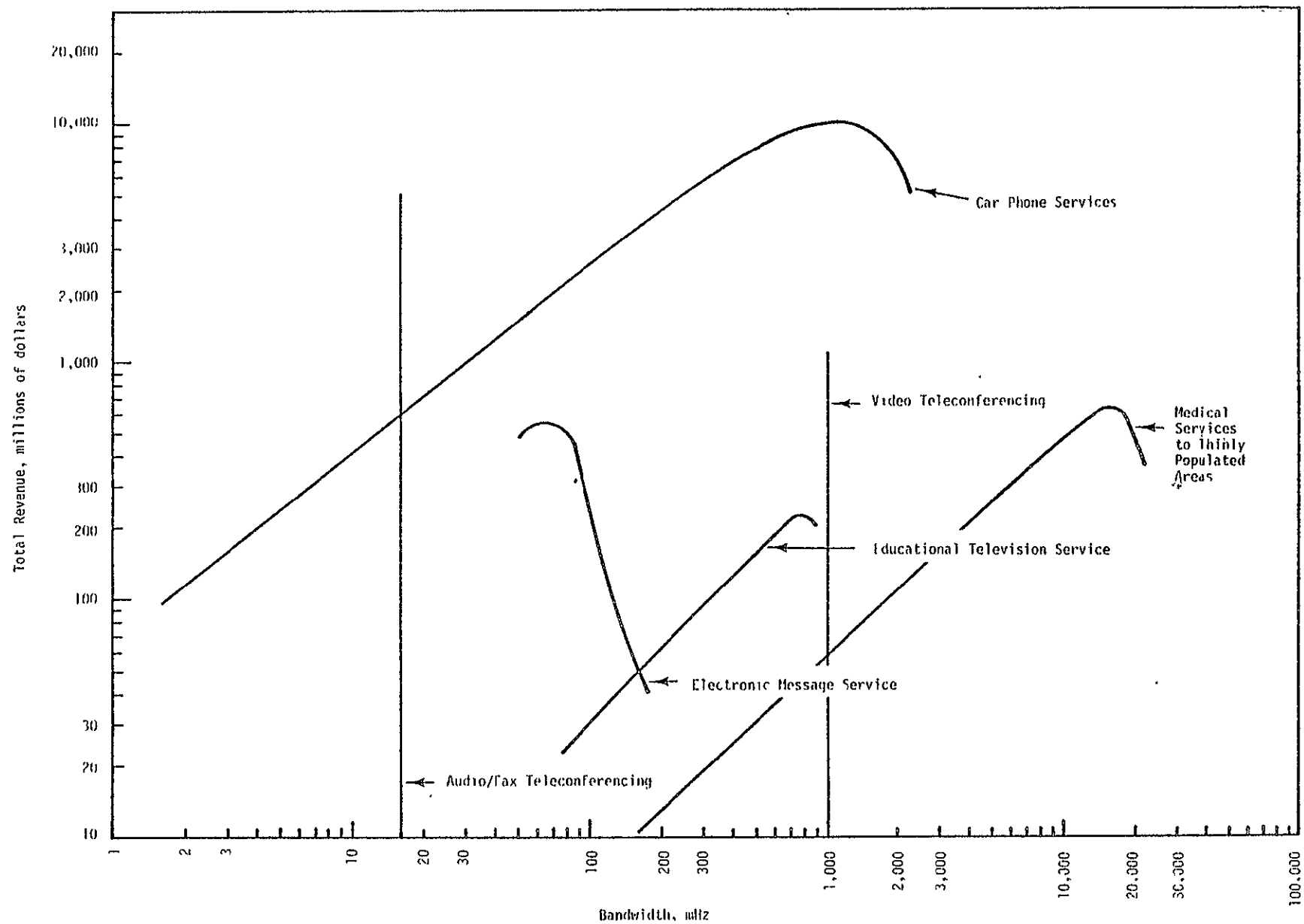
The accompanying figure shows the revenue-bandwidth relationships for the five services considered in this study. As is conventional, revenue is defined as the product of price times quantity,

$$R_i = P_i \times Q_i$$

and for this study, revenue includes the price paid by the consumer for all functions necessary to perform the communications service (for example, for teleconferencing, the price includes the travel cost and time spent, if any, in traveling to and from conference centers as well as the expenditure for the communication services). Viewed in this light, the results of this study indicate that the bandwidth required to maximize revenue (this, it should be noted, is not necessarily the bandwidth required to maximize net benefits) from the Medical Communications Services exceeds the bandwidth needed to maximize revenue from all of the other services considered in this study combined. Thus, on the basis of this study, it would appear that the use of communications to supplement medical services in thinly populated areas could be the driving factor in establishing the bandwidth requirements of a public service satellite. On the other hand, the largest potential revenue producing services are the car phone service and teleconferencing.\*

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\*It should be noted that revenue is not net income, nor is it an estimate of benefits, as the cost of providing the service has not been considered in this study.





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## CONCLUSIONS

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## Conclusions

This brief study of the demand for public service telecommunications considered the demand in the public sector for a set of new services that are either presently experimental, or are now being provided on an extremely limited basis. An econometric model of the existing telecommunications industry was used to examine the economic behavior of the existing industry. The results of this econometric model indicate that the demand for telecommunications services is more dependent upon income than price, and the R&D expenditures reduce capital and labor requirements and increase productivity. The new services considered in this study may be broadly classified as public social services, and public business and personal services. The results of this study indicate a substantial demand for these new services, with potential gross user expenditures for the selected communication services varying from a low of \$220 million per year for an educational television service with national coverage, to approximately \$9,700 million per year for a nationwide car phone service. The study does appear to indicate that the consumers of public business and personal services may be willing to pay higher prices than the consumers of public social services.

## Conclusions

- Two Types of Communications Services
  - + Public Social
  - + Public Business and Personal
- Public business and personal service consumers may be willing to pay higher prices than public social service consumers.
- Econometric model of national telecommunications industry indicates that:
  - + Demand for telecommunications is insensitive to price changes
  - + Income is more important than price in establishing demand
  - + R&D expenditures reduce capital and labor requirements and increase productivity

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RECOMMENDATIONS  
FOR FUTURE WORK

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## Recommendations for Future Work

~~-----~~The present study has considered a limited set of public communications services. The demand for other obvious public communications services was not examined in this brief effort. The demand for these additional services should be examined in future work.

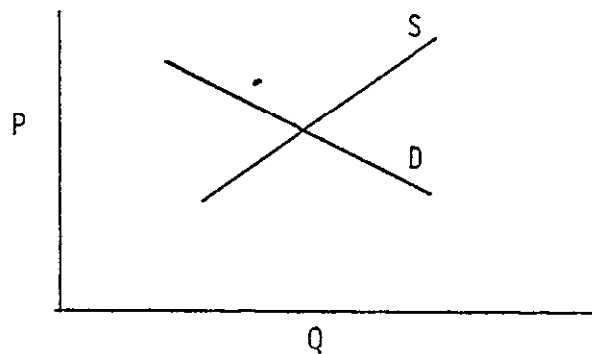
An econometric model of the traditional telecommunications industry was developed in this study and used successfully to estimate the economic behavior of the existing telecommunications industry. Because of the limitations of this study, it was not possible to use the econometric model as a simulation tool to examine the potential economic behavior of this industry under alternative assumptions for the future. It is recommended that the use of the econometric model as a simulation tool be accomplished in the next phase of this study.

In order to estimate the economic benefits of a new public service communication capability, it is necessary to extend the present work to consider supply as well as demand relationships. When the supply and demand relationships can be expressed for each service, it will be possible to estimate the overall economic benefits of each service. Case studies of specific service applications should be accomplished as a part of these benefit/cost studies.

Since benefits depend not only upon potential demand but the actual demand (i.e., customers for the service) and the specific timing of the introduction of service and the method and form of introduction, it is necessary to analyze the various strategies for demonstration and experimentation leading to commercialization. It is recommended that a study be undertaken which will lead to the formulation of an integrated plan for achieving public communication satellite services on a commercial basis. The plan must integrate technology development, program or information content development, case studies and methodology for reducing private sector uncertainty and risk--in short, the plan should detail how an R&D program can result in commercial services and what the R&D program should be.

### Recommendations for Further Work

- Examine demand for other services not covered in 90 day task
  - + Public Safety
  - + Teleconferencing Substitute for Short Trips
  - + Satellite Printing of Newspapers
  - + Library Services
  - + Wide Band Rural Communications
- Use the econometric model as a simulation tool to estimate the impact of alternatives on the economic behavior of the telecommunications industry.
- Formulate methodology to estimate supply curves, leading to capability to estimate benefits for each service.



- Review to select potential areas for case studies
- Formulate plan for R&D program and approach to commercialization



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